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THE HEIGHT OF TROPICAL CYCLONES AND OF THE "EYE" OF THE STORM

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The opinion has often been expressed that tropical cyclones are very flat disturbances. In Hann's "Lehrbuch der Meteorologie" (4th edition, 1926), page 620 ffg., it is stated that they are mostly phenomena restricted to the lowest layers of the atmosphere, or at least their active vortex does not reach very high; similarly, Mrs. E. V. Newnham [1] assumes that the height of tropical cyclones is small. This opinion is based on the observation that tropical cyclones decrease rapidly in intensity when passing over land, particularly in crossing even small mountain ranges. Such a case was reported by John Eliot [2] for the Backergunge cyclone of October 1876, which was "completely broken up by the hills (3,000–6,000 feet) in eastern Bengal and South Assam." Other observations are cited by Mrs. Newnham.

The reported rapid disintegration of the Backergunge cyclone over hills apparently does not hold for typhoons in general, however. Unfortunately there is no observational material for this cyclone which could enable us to study this phenomenon more closely. Cline [3] has shown that in the tropical cyclone of August 17–22, 1915, the amount of rainfall decreased by about one-half when the cyclone reached the low mountainous region of western Arkansas (1,500–2,500 feet) but markedly increased again upon reaching the level lands of the central Mississippi Valley. Likewise the observations mentioned by Mrs. Newnham seem to show that cyclones regenerate after having crossed mountain ranges. We may, therefore, conclude that the influence of mountain ranges of moderate height, while diminishing the intensity of the cyclone to a certain degree, does not dissipate the whole disturbance. It seems rather that the cyclone regains its former intensity after having crossed the obstacle. Sir Napier Shaw [1] has expressed the opinion that a mountain range might possibly cut off the lower part of a cyclone, so that this part would have to be rebuilt after the cyclone had reached level country again. Thus the annihilation of tropical cyclones by mountain ranges does not really give an indication of their height; and the not infrequently reported regeneration of cyclones after they have crossed mountain ranges would rather indicate that the dynamical conditions extend to high altitudes. Without going into more detail it may be said that the common arguments in favor of a small vertical extension of tropical cyclones seem rather weak. On the other hand, good reasons can be brought forth in favor of the view that tropical cyclones have about the same height as those of middle latitudes.

[1] Newnham, Mrs. E. V.: Hurricanes and Tropical Revolving Storms (with an introduction on the Birth and Death of Cyclones, by Sir Napier Shaw). Geophys. Memoir No. 19, Meteorological Office, London, 1922, p. 232.
[2] Eliot, John: Handbook of Cyclonic Storms in the Bay of Bengal. Calcutta, 1900, p. 228.
[3] Cline, I. M.: Tropical Cyclones. New York, 1926, p. 100.

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HEIGHT OF PRESSURE EQUALIZATION AND REQUIRED LAPSE RATES

W. Köppen [4] has pointed out that an unreasonably high temperature would be required in the central part of a hurricane if the pressure difference between center and outer parts were to be smoothed out at an altitude of, say, 3 km. It should be mentioned in this connection that the elevation where the pressure is uniform, or, more exactly, equal to the general pressure distribution in the region, cannot really be regarded as the upper limit of the cyclone. Above this altitude the pressure gradient may, and probably does, have the opposite direction, in order to allow the air which flows inward in the lower strata of the hurricane to flow out again. However, we may take the height of the surface of pressure equalization as an index of the vertical extent of a hurricane.

We shall now try to obtain some information about the height of a hurricane by computing the change in the vertical lapse rate of temperature necessary to smooth out at different elevations the decrease of pressure observed at the ground. For simplicity we shall use for this computation the mean temperature of the whole air column, as the results thus obtained differ but little from those which the exact barometric formula for a linear lapse rate would give.

Let P be the pressure at the ground; p, the pressure at the level, h, of uniform pressure; T_m, the mean temperature; g, gravity; and R, the gas constant for air ($g/R=3.042\times10^{-2}\,°/m$). Symbols which refer to values in the undisturbed area outside the cyclone will be indicated by the index 1, while the index 2 refers to the interior of the cyclone. Then we get as the condition that the pressure at the altitude h be uniform,

$$p_1=p_2,$$

or by means of the barometric formula,

$$P_1 e^{\frac{-gh}{RT_{m1}}}=P_2 e^{\frac{-gh}{RT_{m2}}},$$

which gives for the difference of the mean temperatures [5]

$$\frac{T_{m2}-T_{m1}}{T_{m1}T_{m2}}=\frac{R}{g}\frac{1}{h}ln\frac{P_1}{P_2}, \tag{1}$$

or

$$T_{m2}=\frac{T_{m1}}{1-\frac{R}{g}\frac{T_{m1}}{h}ln\frac{P_1}{P_2}}$$

[4] Köppen, W.: Met. Zeit., 1920, vol. 37, p. 328.
[5] It would be shorter to derive an equation for the difference of the mean temperatures by differentiating the barometric formula. However, the actual differences under examination are too large to allow the application of such a formula.

If we know the mean temperature of the air column, its lapse rate can be assumed approximately as

$$\alpha=2\frac{T_o-T_m}{h} \qquad (2)$$

Before we give a numerical discussion of the lapse rates necessary to compensate the surface pressure differences at different altitudes, the behavior of the surface temperature in different parts of the center of a tropical cyclone should be discussed. The temperature records of some cyclones traveling over the southern United States, published by I. M. Cline,[6] show no evidence of a higher surface temperature toward the center. In some instances the thermograph shows a slightly higher temperature while the station is near the center of the storm; in other cases, however, the temperature is lower. It is true that these cyclones, having traveled over land for a longer or shorter time, have partly lost the characteristic qualities of tropical hurricanes; but since we have no other observations we shall accept Cline's opinion that these temperature changes result mainly from the cloudiness which cuts off the insolation. We therefore assume first that the surface temperature is uniform, and choose the following numerical values: The surface temperature may be 300° *A* (81° *F.*), and the lapse rate outside the cyclonic area $\alpha_1=0.6°/100m$; that would make $T_{m1}=291°$ for an air column 3 km high, $T_{m1}=282°$ for an air column 6 km high, and $T_{m1}=270°$ for an air column 10 km high. The surface pressure outside the cyclonic area may be 1,010 mb (29.82 in.); the pressure in the center may be 970 mb (28.64 in.). This value for the lowest pressure is certainly a very conservative assumption; however, this will only strengthen our argument. The formulae (1) and (2) show that it would require a mean temperature of $T_{m2}=328°$ to smooth out the pressure drop at the surface at an elevation of 3 km. That would mean an *increase* in temperature with elevation, of 1.87° C./100 m in the central parts of the cyclone. We have no means of accounting for such an exceptionally high temperature in hurricanes, and therefore the conclusion is unavoidable that the surface of pressure equalization must be much higher. If it should be at an altitude of 6 km, the mean temperature in the central part should be $T_{m2}=299°$, which corresponds to a vertical temperature decrease of .03° C./100 m, or an almost isothermal state. If we put $h=10$ km, we get $T_{m2}=279°$, and $\alpha_2=.42°$ C. per 100 m. It is highly improbable that there is an isothermal condition up to 6 km in any tropical cyclone and it therefore seems reasonable to assume that the surface of pressure equalization is at an elevation of 10 km rather than 6 km.

This opinion is strengthened by the results of Horiguti's [8] investigations of the typhoons of the Far East. In these cyclones the temperature decreases slightly toward the center on land; the difference between the outer and inner parts is about 2° C. At sea the temperature increases slightly toward the center by about the same amount, but only on the front side, remaining fairly constant over the entire rear side. We should also keep in mind here that these typhoons after traveling over land have lost many of their characteristic qualities.

OBSERVED LAPSE RATES IN TYPHOONS

Especially interesting in Horiguti's investigations of the temperature distribution in typhoons is the fact that he could also obtain some determinations of vertical temperature gradients from observations on Mount Tukuba (869 m.), Mount Bessi (788 m.), and Mount Ibuki (1,376 m.). While it is true that temperature gradients obtained from mountain observations are rather unreliable indicators of the temperature gradients in the free atmosphere, since they are very much influenced by the topography, we shall discuss them here for lack of other observations. Horiguti summarizes these observations by stating that the lapse rate is about 0.6° or 0.7°/100 m or even greater in the outer part of a typhoon, and about 0.5°/100 m in the inner part. If we may assume that these mountain values for the lowest layers are representative of the values of the lapse rate in the free atmosphere, we see that they indicate a higher mean temperature in the central parts of the hurricane. However, this higher mean temperature is not nearly sufficient to cause a uniform pressure distribution in the lowest layers of the atmosphere, as we shall presently show, for even the most favorable of Horiguti's cases. Horiguti's material contains only two cases in which lapse rates could be determined when the pressure values were less than 740 mm (29.13 in.). In one of these cases, however, the lapse rate was practically the same both inside and outside the central part of the typhoon, so that only at greater elevations over the mountain can the temperature compensation of the drop in surface pressure take place. The other observation was made during the typhoon of August 4, 1920, at Mount Ibuki and at Hikone (88 m, 23 km to SW.). The following values were obtained: [9]

TABLE 1.—*Lapse rates in a typhoon*

Date	Hikone		Mount Ibuki		Lapse rate	Distance from center
	P	*T*	*P*	*T*		
1920	*mm*	° *C.*	*mm*	° *C.*	° *C./100 m*	*km*
Aug. 1	750.1	26.8	647.1	17.4	.73	1,000
Aug. 2	48.6	25.9	45.3	17.7	.64	800
Aug. 3	44.8	26.1	41.8	17.6	.66	700
Aug. 4	35.8	22.9	33.9	15.7	.48	200
Aug. 5	38.2	22.1	35.4	13.4	.68	400
Aug. 6	42.7	22.9	40.0	14.3	.67	(1)

[1] Outside of the depression.

If we choose, for instance, the values at 800 and 200 km from the center, we can reverse our previous question and compute the elevation at which the pressure will be uniform under the assumption that the lapse rates found between mountains and valleys hold throughout the whole layer under consideration.

By means of formulae (1) and (2), we obtain the equation

$$\left[\frac{g}{R}\frac{\alpha_2-\alpha_1}{2}+\frac{\alpha_1\alpha_2}{4}ln\frac{P_1}{P_2}\right]h^2+\left[\frac{g}{R}(T_1-T_2)-\frac{\alpha_1T_2+\alpha_2T_1}{2}ln\frac{P_1}{P_2}\right]h+T_1T_2ln\frac{P_1}{P_2}=0 \qquad (3)$$

where the indices 1 and 2 refer to the values in the inner and outer parts of the cyclone respectively. With the values published by Horiguti, equation (3) gives for h, 8,950 m. If instead of the values for 800 km, we take these for 700 km distance from the center, we find $h=7{,}520$ m. Both values indicate as clearly as the previous example that the drop in pressure cannot be smoothed out in the lowest layers of the atmosphere, even though we could use only data from the less violent parts of the typhoon. Here again we have used temperature distribution data which were obtained in hurricanes

[6] I. M. Cline, loc. cit., pp. 205, 206, New York, 1926.

[8] Yosiki Horiguti, On the Typhoons of the Far East, Part II. Mem. Imp. Mar. Obs. Kobe, Japan, 1927. Vol. III, no. 2.

[9] Horiguti, *loc. cit.*, p. 61.

weakened by moving inland, but it can be seen from the foregoing discussion that this unreliability of the data does not affect our argument in favor of a vertical extent of the hurricane through at least the whole troposphere.

WARMTH AND DRYNESS OF THE "EYE" OF THE MANILA TYPHOON

So far we have assumed that the surface temperature is uniform throughout the area of a cyclone, an assumption which was based upon I. M. Cline's work and upon Horiguti's observations. There are cases reported, however, when the temperature rose considerably with the approach of the storm center. In the Manila typhoon of October 19–20, 1882,[10] the temperature was fairly uniform at about 24° C. until the center approached. In the calm the temperature rose suddenly to 31.6°; then fell to about 25° after the center had passed. If we assume this rise in temperature of 8° is characteristic of the difference in the mean temperature of the air in the outer and inner zones of the hurricane, we can see, without computation, from our first example that the surface of equal pressure can hardly be below 10 km. We assumed there a drop in pressure of 40 mb, which corresponds to the values in the Manila typhoon, and we saw that an increase of 9° in the mean temperature is required to smooth out this effect at 10 km elevation. The relative humidity, which was almost 100 percent immediately before and after the calm, dropped to 49.7 percent.[11] The rise in temperature may be due to insolation, according to Algué, in spite of a continuous "veil of condensed vapor." If the change in relative humidity had been caused by insolation of the same air mass that was present before the calm, we should expect to observe a drop in relative humidity to about 61 percent; but the air in the center is very much drier, indicating that in the eye of the storm we have a downward current which brings warm and dry air to the ground. This air in the center probably comes from the surrounding regions of the cyclone, and has lost part of its moisture content by precipitation during previous ascent.

The innermost part of the cyclone, the calm center, seems to be composed of warmer and drier air than the outer part. If we assume that the rise in temperature observed at the ground is characteristic of the difference between the mean temperatures of the air in the calm and in the outer part, the height of the surface of pressure equalization will be about 10 km.

NEGLIGIBLE EFFECT OF MOISTURE AND VERTICAL ACCELERATIONS ON PRESSURE DISTRIBUTION

A few words must be added about the influence of the moisture content and the effect of vertical accelerations on the pressure distribution. It is generally recognized that both factors are very small, but they will be discussed here for the sake of completeness. It is known that moist air under the same pressure and temperature is lighter than dry air and that it is therefore possible in many problems of atmospheric statics to treat the actual moist air as dry air of a higher, "virtual" temperature T'. If T is the actual temperature, e the vapor pressure, p the air pressure, we have

$$T'=T\left(1+0.377\frac{e}{p}\right)$$

A temperature of 27° C. and saturation, for instance, would give $e=35.6$ mb and with $p=1010$ mb, $T'=300°+4°$. This value of 4° C. is fairly high and will seldom occur actually. However, let us assume, for the sake of the argument, that the moisture content is so high that the mean temperature of the whole air column is increased by the same amount. (It is hardly necessary to mention that this assumed condition is impossible, since the specific humidity decreases with elevation.) If we return to our first example, we see that we could reduce the actual mean temperature in the inner part by 4°, provided that the outer regions have no moisture content, while the interior part contains the excessive amount just assumed; but even then we should find a lapse rate of only about 0.17°/100m, if we assume that the horizontal pressure differences are smoothed out at 6 km elevation. Furthermore, the existence in the strongest cyclones of an "eye" with its dry air shows that here the influence of the moisture content in the central part can hardly contribute to the decrease of the pressure.

Still more negligible is the influence of vertical accelerations. Let ρ be the density, p the pressure, z the height, g the acceleration due to gravity, and w' the acceleration of the air (which we assume to be constant). We see, then, from the equation for the vertical motion,

$$-\frac{1}{\rho}\frac{\partial p}{\partial z}=g+w'=\bar{g}$$

that the effect of the vertical acceleration can be interpreted as a slightly changed gravity acceleration, somewhat larger with upward acceleration and smaller with downward acceleration. Therefore the influence of vertical acceleration upon the surface pressure, under the assumption that the pressure p at an elevation z remains unchanged, is easily obtained by differentiating the barometric formula with respect to g. If we again write w' for dg we obtain

$$\frac{dP}{P}=\frac{z}{RT_m}w'.$$

In order to judge of the possibility of such values of w' as we might compute by assuming certain values for dP, P, z and T_m we must remember that

$$w=\sqrt{2w'z}=\sqrt{2RT_m\frac{dP}{P}}$$

provided that w' is constant. If we put $dP=1$mb, $P=1010$ mb, $T_m=267°$ we obtain for different altitudes:

TABLE 2.—*Vertical acceleration and velocity required for an appreciable effect on pressure*

z	3.10^3 m	6.10^3 m	10.10^3 m
w'	$2.5.10^{-4}$	$1.26.10^{-3}$	$.76.10^{-3}$ m/sec.^{2}
w	12.3	12.3	12.3 m/sec.^{2}

These values are by far too high, so that evidently the vertical acceleration has practically no influence on the pressure distribution even in tropical cyclones. It might be added that in tornadoes, owing to their much more violent vertical motions, the influence of vertical motions on the pressure distribution is probably appreciable; but this vertical acceleration could not take care of even part of the drop in the surface pressure toward the center. Indeed, since we have an increased upward motion and therefore an increased upward acceleration toward the center, we should expect a rise in pressure in this direction if everything but the vertical acceleration remains unchanged.

[10] J. Algué, S. J.: The Cyclones of the Far East, 2d ed., Manila, 1904.
[11] Or 43 percent, according to the observations of Fr. Faura, cit. by Algué, *loc. cit.*, p. 57.

THE FUNNEL OF WARM DRY AIR IN A HURRICANE

We have heretofore been concerned only with the pressure differences between two particular points, namely, the center and a place at the outer limit of the hurricane. Going one step further, if we take for granted that the central air column of the hurricane consists of a drier and (which is more important at present) warmer air mass than the outer part, we may assume that the boundary between these two air masses has a form such as indicated in fig. 1, a funnel, the surface of which curves outward

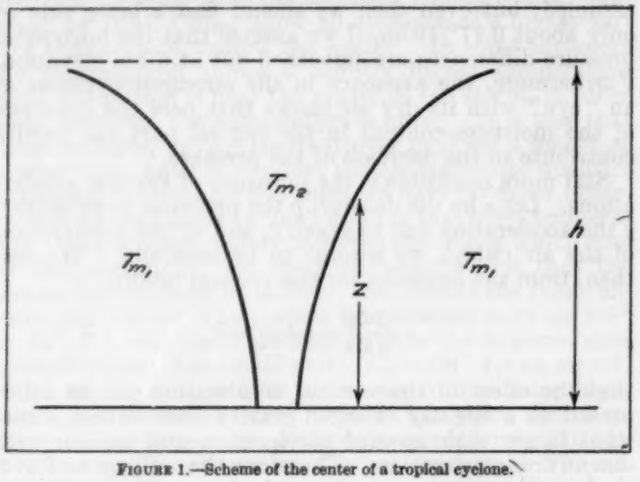

FIGURE 1.—Scheme of the center of a tropical cyclone.

with elevation. Such a shape has been suggested by other writers. We can now try to get more information about the shape of this funnel by assuming two different mean temperatures, T_{m_2} for the air inside the funnel, and T_{m_1} in the outer part. Then we can compute at what altitude the colder air of temperature T_{m_1} has to be replaced by the warmer air of temperature T_{m_2} in order that at an elevation h the pressure will be uniform. Since the pressure at the elevation z is

$$p_z = Pe^{-\frac{g}{R}\frac{z}{T_{m_1}}}$$

and the pressure at the elevation h is

$$p_h = p_z e^{-\frac{g}{R}\frac{h-z}{T_{m_2}}} = Pe^{-\frac{g}{R}\frac{z}{T_{m_1}}-\frac{g}{R}\frac{h-z}{T_{m_2}}}$$

we get

$$z = \frac{R}{g}\frac{T_{m_2}T_{m_1}}{T_{m_2}-T_{m_1}}\left(ln\frac{P}{p_h}-\frac{gh}{RT_{m_2}}\right) \qquad (4)$$

For a numerical example, let

$$T_{m_1}=267°,\ T_{m_2}=275°,\ P_1=1{,}010\ mb,\ P_2=970\ mb$$

These figures are chosen so as to agree with the data for the Manila typhoon of October 20, 1882. The mean temperature, T_{m_1}, is computed on the assumption of a surface temperature of 24° C., a lapse rate of 0.55° C./100 m and a height h of 10,860 m for the surface of pressure equalization. This height can at once be found by means of formula (1).

A second possibility for the determination of h is given by formula (4): The elevation z of the boundary must become 0 at the beginning and end of the calm zone. We can therefore put $z=0$ in formula (4) and introduce for P the pressure value observed at the borders of the calm. We thus arrive at two equations for the three quantities h, T_{m_1}, T_{m_2}. If we choose T_{m_1}, for instance, according to the surface observations and with reasonable assumptions as to the lapse rate in the outer part we can compute h, the surface of pressure equalization, as we have just done for the Manila cyclone, and in addition T_{m_2}, the mean temperature in the central part. In practice, however, a deficiency of our theory manifests itself here. According to Algué the pressure was not constant during the passage of the calm, but had already begun to rise when Manila entered the calm zone, showing that the center of motion lags behind the center of pressure. That may be due to the progressive motion of the cyclone as a whole, [12] [13] which we disregarded in deriving our formulae in order to simplify matters and to work out the essential points more clearly. We shall therefore have to be content to assume plausible values for T_{m_1} and T_{m_2} and compute h only. The results which we obtain in this way show that we are not very far from the truth in spite of our neglect of the progressive motion of the cyclone. It will, however, be worth while to keep in mind that with a more detailed theory we would be able to restrict our assumptions further.

Having found h we can at once determine P_h, the pressure at the surface of pressure equalization. Then we can find from formula (4) the elevation z of the boundary between the inner and outer air masses as a function of the surface pressure P. The result is partly given in the following table, and is plotted in figure 2. As abscissa we have chosen the distance from the center instead of the surface pressure. This could easily be computed, since Algué gives the velocity of the hurricane at 19 nautical miles (35.2 km per hour) and states that the center passed Manila on October 20, 1882, at 11:52 a. m. This speed could have not been quite constant, hence our abscissa may not be exact; however, we can be sure that its accuracy is within reason.

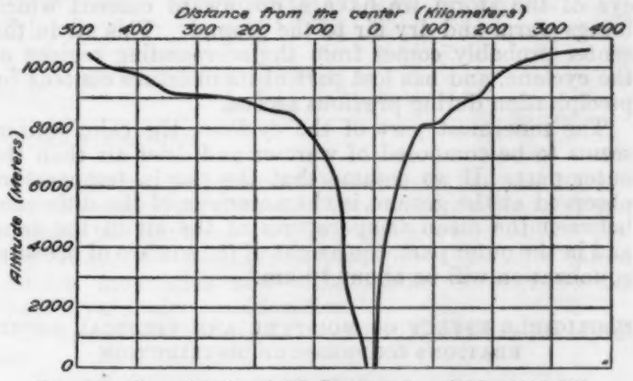

FIGURE 2.—Shape of the funnel of the Manila cyclone, October 19-20, 1882.

Table 3 and figure 2 give the funnel-shaped form of the "eye" of the storm. The two sides of the boundary have not exactly the same shape. The boundary is steeper on the rear side than on the front side of the cyclone. That is, of course, closely connected with the fact that the isobars, as happens frequently, are crowded together on one side of the cyclone; but this cannot be regarded as an explanation; it is just another manifestation of the same phenomenon, since we used the surface pressure for the calculation of the height of the boundary. The crowding of the isobars in one direction is probably in many cases an effect of the progressive motion of the cyclone as a whole.

[12] In other cases, however, the center of pressure lags behind the center of motion. It is therefore possible that our simple kinematic explanation does not hold even in the case of the Manila cyclone, but that other influences are at work which bring about the displacement of both centers with respect to each other.

[13] cf. Th. Hesselberg, Über das Verhältnis zwischen Druckkraft und Wind. Geofys. Publik., Vol. IX, No. 8, Oslo, 1932.

TABLE 3.—*Height of the boundary of the "eye" of the Manila cyclone, Oct. 19–20, 1882*

Before passage of center		After passage of center	
Distance from center	Height of boundary	Distance from center	Height of boundary
km.	m.	km.	m.
312	9,100	40	5,830
243	9,000	75	8,050
171	8,530	110	8,150
101	7,590	180	9,060
66	6,410	251	10,100
48	3,460	321	10,500
30	1,740		

We do not claim that the boundary of the calm zone as represented by figure 2 is in all respects a true boundary in the sense that no air can cross this surface. It might well be that only the inner steep part is a boundary in this hydrodynamical sense of the word, while the more horizontal part is rather a transitional zone where the air changes its qualities more rapidly.

Formula (4) may also be derived by means of the relation between the inclination of a surface of discontinuity and the velocity and density distribution on both sides. This deduction shows that formula (4) is also in agreement with reasonable assumptions about the wind distribution in a tropical hurricane.

SOUNDING-BALLOON OBSERVATIONS AT OMAHA, NEBR., DURING THE INTERNATIONAL MONTH, JANUARY 1934

By J. C. BALLARD

[Weather Bureau, Washington, D. C., January 1935]

The Weather Bureau conducted a series of sounding-balloon observations at Omaha, Nebr., during the international month, January 1934. The observations were made in cooperation with the International Commission for the Exploration of the Upper Atmosphere, and the program followed was similar to that for other series of this nature except for the addition of some special observations. The latter included a total of 5 observations on the 21st and 22d, 2 on the 24th, and 5 on the 30th.

It was intended to make the special observations during the passage of a low-pressure area over the station, to obtain a cross-sectional picture of the meteorological conditions. No satisfactory condition occurred during the month, however, so the instruments for special use were released as indicated below. Those of the first set (on the 21st and 22d) were released in the southern part of a LOW, those of the 24th were made during the advance of a cold wave, and those of the 30th were made to determine whether a slower rate of ascent would result in greater altitudes being reached by the balloons before bursting. The reason for expecting better altitude performance from a nearly floating balloon lies in the fact that at low temperatures more time is required for the rubber of the balloons to stretch to the fullest extent than at higher temperatures. The best altitude performance from a slowly rising balloon probably would be obtained in the daytime, but the temperature record would then be of little value.

For a description of the instrument used, the method of attachment, etc., and a record of previous sounding-balloon series in this country, the reader is referred to the following issues of the MONTHLY WEATHER REVIEW, in which either references or descriptions will be found: January 1932; February 1934; April 1934.

Most of the observations were made during daylight hours, so that the balloons could be followed by theodolite; and even though they were made as late in the day as practicable, the temperature records probably were affected by insolation. However, the amount of this effect could not be determined because of lack of a sufficient number of night flights (1).

Detailed data obtained from the observations will be published by the International Commission for the Exploration of the Upper Air.

A summary of the individual observations will be found in table 1. Altogether 46 instruments were released and all but two were found. Two of the records were destroyed by the finders. Of the remaining 42 records, 38 were good; and at least 1 good record was obtained on all but 3 days during the month.

The highest altitude reached was 29.3 km on the 10th, and a height of 20 km was exceeded seven times. The average height reached in those flights in which the record was good up to the maximum altitude was 17.5 km.

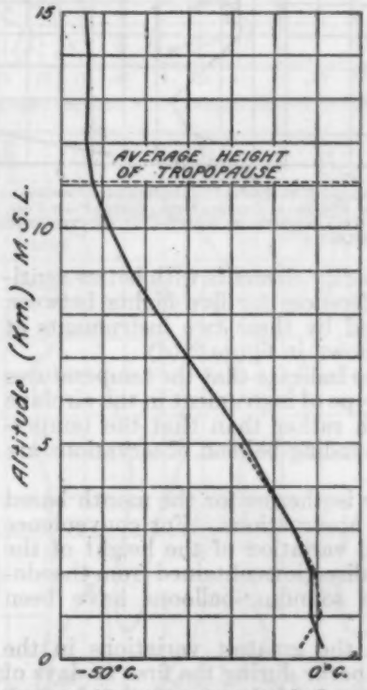

FIGURE 1.—Mean temperature curve for January 1934 at Omaha, Nebr. Solid line based on late afternoon sounding-balloon observations and dashed line on early morning airplane observations.

The greatest height of the tropopause observed during the month was 14.2 km, on the 10th; and the lowest, 7.9 km, on the 12th. The average height was 11.1 km.

Figure 1 shows the average temperature curve for the month, obtained by the difference method from the regular flights made near 4 p. m. (the special observations were not considered) and the mean temperatures for the month obtained from the airplane observations made near 4 a. m. It will be noted that the morning temperatures observed by airplane averaged higher above 800 meters (m. s. l.) and lower above 3,000 meters (m. s. l.) than the afternoon temperatures observed by sounding balloon, in spite of the fact that due to diurnal variation the temperature below 1,500 meters (m. s. l.) averages lower in the morning than in the afternoon (2).

As a further check on the agreement between the temperatures observed by the two methods, the Polar Year observations were used (1). On 2 days per month during the Polar Year, sounding-balloon observations were made near 6 a. m. On each day on which one of these sounding-balloon observations was available, to-

gether with an airplane observation made near 4 a. m., the temperature differences between the two types of observations, at the standard levels, were found and the averages obtained. The results for Dallas, Tex. and Omaha, Nebr., are shown in figure 2, together with the results obtained during January 1934, at Omaha.

It will be seen that the surface differences in each case are in accordance with what would be expected from a knowledge of the diurnal variation. The differences in the free-air, however, cannot be explained in this way. The differences at Omaha during the Polar Year and during the month of January agree fairly well. The differences at Dallas agree well in the lower levels with those at Omaha, but at the higher levels the temperatures obtained by airplane at Dallas average higher than those obtained by sounding balloon, while the reverse is true at Omaha.

Recently some test flights were made in which two airplane instruments were carried simultaneously on the airplane. One instrument was the standard type aerometeorograph now in use by the Weather Bureau and the other was a new type of instrument designed to provide

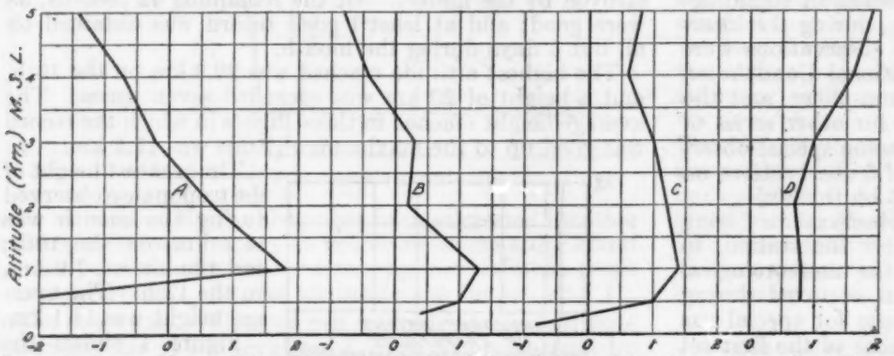

FIGURE 2.—Average difference (°C.), temperature observed by airplane minus temperature observed by sounding-balloon, (a) at Omaha, Nebr., during January 1934, (b) at Omaha, Nebr., during Polar Year, (c) at Dallas, Tex. during Polar Year; and (d) average difference (°C.) temperature observed by old-type aerometeorograph minus temperature observed by new-type aerometeorograph.

the temperature and humidity elements with better ventilation. The average differences for five flights between the temperatures recorded by these two instruments at the standard levels are shown in figure 2 (d).

The evidence appears to indicate that the temperatures recorded by the present type of instrument in the airplane observations are too high rather than that the temperatures recorded in the sounding-balloon observations are too low.

Figure 3 shows free-air isotherms for the month based on the sounding-balloon observations. For convenience of reference the observed variation of the height of the tropopause and the wind directions obtained from theodolite observations of the sounding-balloons have been added to this figure.

It will be noted that the greatest variations in the height of the tropopause occur during the first 12 days of the month. During this part of the month the sky was overcast at the time of observation on all but two of the days (the 1st and 8th), and the surface temperatures varied but little except on two occasions (the 1st and 7th).

Figure 4, prepared by drawing lines through points of equal departure from the average for the month, shows the extent of the warm and cold air masses more clearly than the chart of isotherms. The frequent inverse relationship between the relative temperatures in the lower and upper atmospheres, i. e., relatively warm in the stratosphere at the same time it is relatively cold in the lower atmosphere and vice versa, is brought out very well in this figure. The pressure changes at the surface, being the results of the temperature change aloft, can obviously be predicted quite accurately from the extent of the warm and cold air masses; but to show this relationship, the surface pressures observed at the times of each of the soundings have been plotted at the bottom of the figure.

The cold wave occurring on the 7th is interesting since the cold area can apparently be traced from the surface upward into the stratosphere. The coldest period in the stratosphere, however, occurred 3 days later than at the surface. A similar situation appears on the 12th. Here the fall was only slight at the surface, increased to several degrees between 2 and 8 km, and occurred 2 days later (on the 14th) in the stratosphere.

On the 7th the center of the cold wave passsed to the north, only the southern edge passing over Omaha. From the data from only one station, it is impossible to say for certain whether there is any direct relationship between the cold air in the stratosphere on the 10th and that at the surface on the 7th, or whether the two are separate and distinct phenomena. That there is or is not any causal relationship between such phenomena can be determined only by frequent high-altitude soundings from a network of stations.

Figures 5 and 6 have been constructed similarly to figure 4, and show the temperature conditions during the special observations taken on the 21st and 22d, and on the 24th.

Figure 5 shows about the average temperature distribution and average height of the tropopause as a LOW approaches from the northwest. As the southerly winds continue, the temperature departure between the surface and 1 km increases until about sunrise, the departure between 1 km and 10 km becomes negative and that between 10 km and 15 km increases. After this time, as the LOW continues to move in an easterly direction, north of and past the station, the temperature continues to rise in the stratosphere and to fall in the lower levels, cold currents appearing at 6 to 8 km around noon, and at 3 to 6 km somewhat later. It is interesting to note (see table 1) that the landing places of the balloons released in this series changed in a regular manner from a direction of 54° (NE. of the station) for the balloon released at 4 p. m. on the 21st, to 123° (SE. of the station) for the one released at 4 p. m. on the 22d.

Needless to say, the series would have been much more valuable if the LOW had moved in a southeasterly direction and passed directly over the station.

Figure 6 shows the front of a cold current passing over the station on the 24th just after the lower layers had been relatively warm. The height of the tropopause decreased somewhat as the cold air came in, and a cold current appeared in the stratosphere at about the same time the front of the cold air mass appeared at the surface.

Of the five instruments released on the 30th with a slow ascensional rate, one was not found, one failed to record, one clock stopped at a height of 6.7 km and another at 16.6 km, and the fifth, with a good record throughout, reached a maximum height of 19 km or 1.5 km higher than the average. Therefore, nothing was learned as to the relationship between the slow ascensional rates and the maximum heights reached.

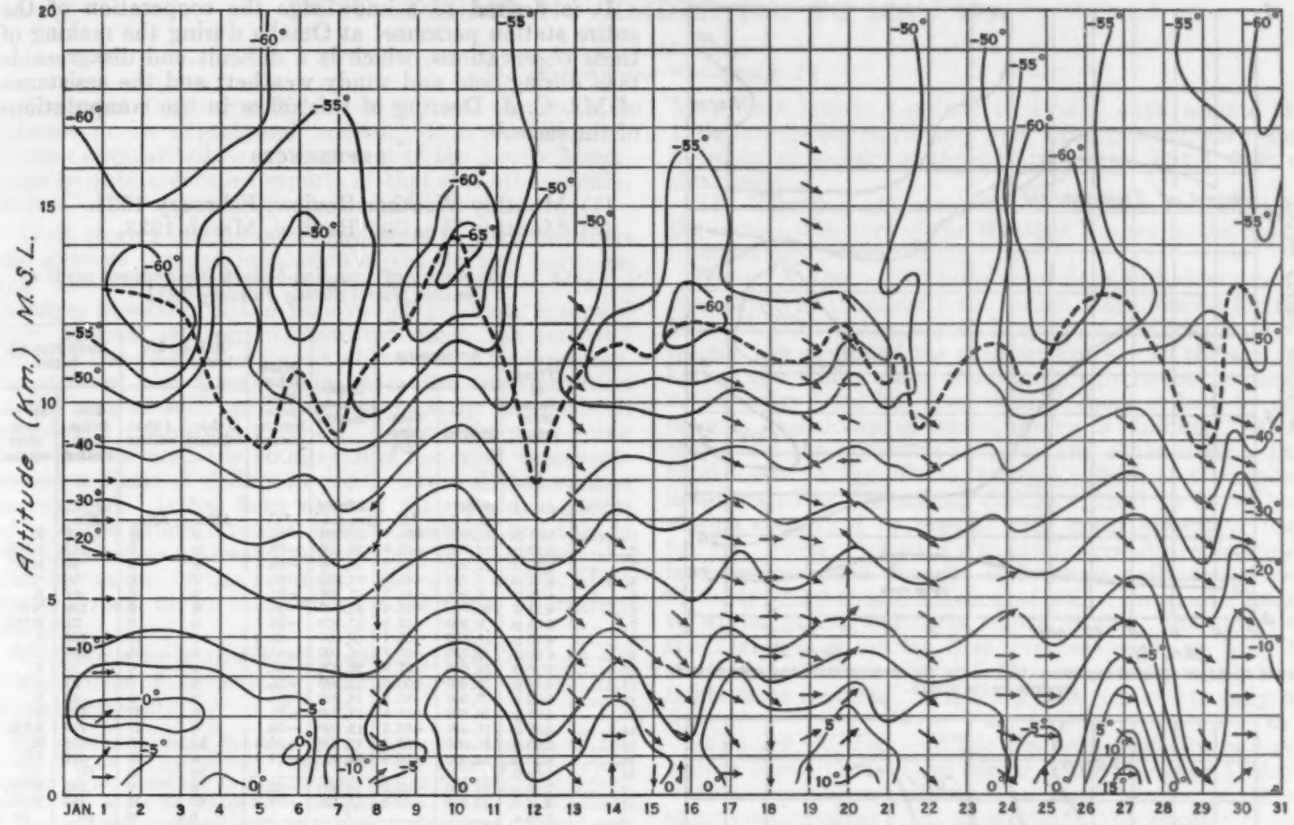

FIGURE 3.—Free-air isotherms (solid lines), height of the tropopause (heavy dashed line), and wind directions (arrows) for January 1934 at Omaha, Nebr.

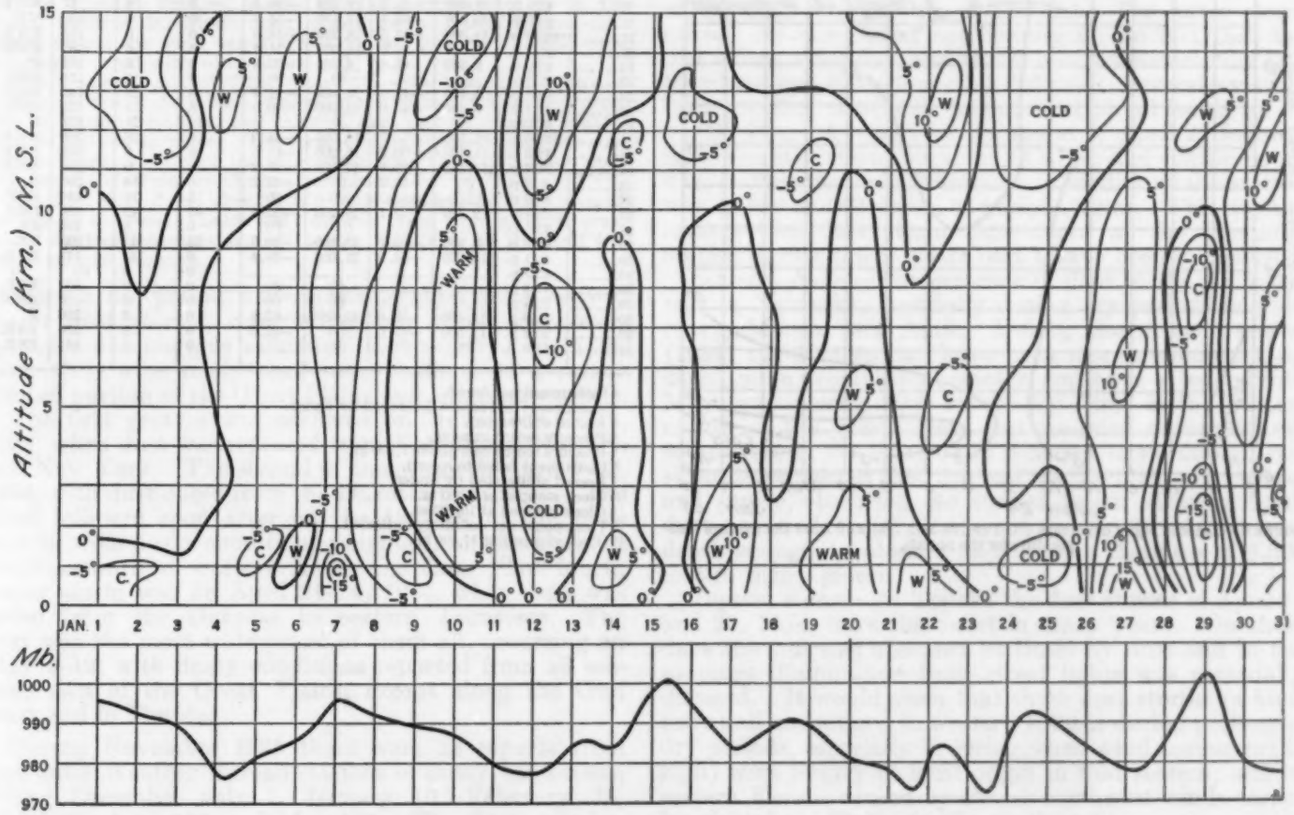

FIGURE 4.—The lines at the top connect points of equal departure (°C.) from the average temperature for the month, and the curve at the bottom shows the surface pressure plotted against day of the month.

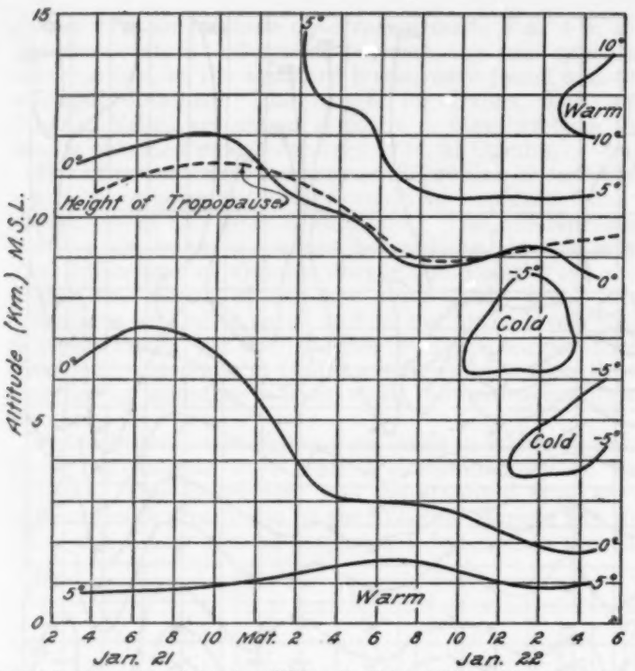

FIGURE 5.—Lines of equal departure (°C.) on the 21st and 22d from the average temperature for the month.

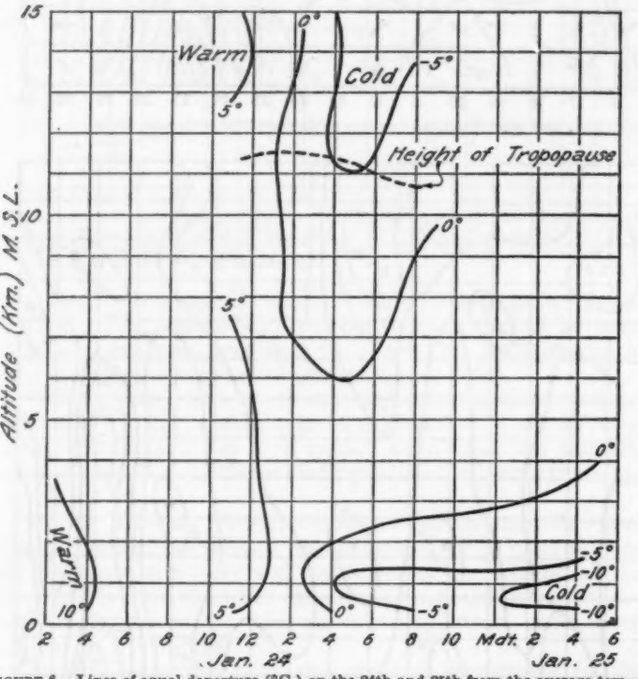

FIGURE 6.—Lines of equal departure (°C.) on the 24th and 25th from the average temperature for the month.

It is desired to acknowledge the cooperation of the entire station personnel at Omaha during the making of these observations, which is a difficult and disagreeable task during cold and windy weather; and the assistance of Mr. C. J. Doering of this office in the computations of the records.

REFERENCES

(1) Monthly Weather Review, February 1934.
(2) Monthly Weather Review, March 1933.

TABLE 1.—*Summary of sounding-balloon observations made at Omaha, Nebr., during January 1934*

Date	Time of release 90th mer.	Tropopause		Maximum height	Minimum temperature recorded	Balloon followed with—		Meteorograph found	
		Height	Temperature			2 theodolites	1 theodolite	Distance from station	Direction from station
		Meters (m. s. l.)	*°C.*	*Meters (m. s. l.)*	*°C.*	*Min.*	*Min.*	*Km*	
1	4:51 p.	12,900	−60.0	21,700	−62.4	0	38	185	E.
2	4:32 p.	12,700	−62.9	20,100	−62.9	0	0	144	ENE.
3	4:26 p.	12,300	−64.4	18,700	−64.4	0	0	99	NE.
4	4:29 p.	9,900	−47.3	17,300	−61.2	0	0	88	NE.
5	4:19 p.	8,900	−47.2	14,800	−54.8	0	0	87	E.
6	4:21 p.	10,700	−52.4	21,800	−56.0	0	0	169	NE.
7	4:25 p.	9,200	−52.8	17,500	−54.7	0	0	71	ENE.
8	4:30 p.	11,300	−59.4	18,000	−59.2	0	43	142	S.
9	4:05 p.	12,700	−67.7	16,100	−67.7	0	0	166	SSW.
10	4:16 p.	14,200	−67.8	29,300	−67.8	0	0	50	E.
11	4:15 p.	11,300	−55.6	12,800	−56.7	0	0	84	NE.
12	4:22 p.	7,900	−47.8	14,900	−51.1	0	0	43	E.
13	4:05 p.	10,600	−51.6	13,200	−51.6	0	57	129	SE.
14	4:09 p.	11,400	−59.3	12,500	−59.7	0	27	197	ESE.
15	4:13 p.	11,300	−56.1	17,200	−56.3	15	15	178	E.
16	8:15 a.	12,000	−62.5	21,400	−63.4	0	23	217	SE.
16	4:09 p.					38	43	(1)	(1)
17	7:45 a.	11,900	−62.1	18,800	−62.1	0	0	123	ESE.
17	3:56 p.	11,800	−59.8	15,100	−59.8	46	51	157	ESE.
18	7:55 a.					0	0	(2)	(2)
18	4:23 p.	11,100	−58.3	15,900	−58.5	33	34	158	E.
19	3:57 p.	11,200	−58.6	17,700	−58.6	0	75	98	ESE.
20	4:01 p.	11,900	−58.5	14,300	−58.5	0	74	47	NNE.
21	4:10 p.	10,600	−55.3	14,400	−55.3	0	0	150	NE.
21	10:20 p.	11,300	−53.5	18,300	−54.0	0	0	158	ENE.
22	3:17 a.	10,500	−51.6	14,600	−51.6	0	0	182	ENE.
22	6:32 a.	9,300	−45.8	16,300	−50.8	0	0	133	E.
22	9:33 a.			(3)	(3)	0	0	175	ESE.
22	1:01 p.	9,200	−48.2	21,400	−51.4	0	25	140	ESE.
22	4:11 p.	9,400	−45.0	18,500	−50.6	0	31	225	ESE.
23	4:10 p.			(4)		10	21	179	E.
24	12:26 p.	11,500	−53.7	18,000	−54.0	0	28	206	ENE.
24	4:23 p.	11,400	−60.3	16,200	−61.5	0	0	295	ENE.
24	7:24 p.	10,800	−56.6	13,700	−57.2	0	0	250	ENE.
25	4:13 p.	(5)	−53.2	(5)	−53.2	0	14	203	E.
26	4:20 p.			(6)	(6)	5	10	184	ESE.
27	3:57 p.	12,700	−59.1	19,700	−59.4	40	42	259	ESE.
28	4:51 p.			(7)	(7)	0	6	384	SE.
29	4:09 p.	8,800	−50.7	15,100	−53.3	33	45	238	SE.
30	4:11 p.	12,700	−54.9	21,000	−59.4	0	43	161	ESE.
30	6:57 p.					0	0	(1)	(1)
30	7:14 p.			(8)	(8)	0	0	233	ESE.
30	7:35 p.			(9)	(9)	0	0	10	ENE.
30	7:50 p.	12,100	−56.6	19,000	−62.8	0	0	250	E.
30	8:12 p.	11,500	−57.0	(5)	−61.0	0	0	270	ESE.
31	4:09 p.	(10)	(10)	(11)		0	0	461	ESE.

[1] Instrument not found.
[2] Instrument and record destroyed by finder.
[3] Record obliterated.
[4] Pressure record missing.
[5] Pressure record bad above 7,700 m.
[6] Instrument failed to record.
[7] Record obliterated by finder.
[8] Clock stopped at 6,700 m.
[9] Clock stopped at 16,600 m.
[10] Tropopause not definitely indicated.
[11] Clock stopped at 17,600 m.

DUST STORMS, NOVEMBER 1933 TO MAY 1934

By W. A. MATTICE
[U. S. Weather Bureau, Washington, D. C.]

The great dust storm of May 9–12, 1934 aroused such interest in its extent and intensity that the Weather Bureau circularized its stations east of the Rocky Mountains to obtain detailed reports of that and other similar storms. The reports are summarized below.

Dust storms cause much discomfort to human beings and animals through inhalation of the drifting particles, and also deposit much dirt generally. Their major damage, however, is the removal of productive topsoil from agricultural regions, however much the removed soil may benefit another region where it may be deposited. In parts of the Great Plains area the transportation of soil was of such magnitude as to strip the fields of tillable soil down to plow depth. Indeed, the wind-borne dust that covered the country this last year represents untold millions of dollars in productive soil that cannot be replaced. It has been claimed that the dust storm adds to the productiveness of soil elsewhere, but that is cold comfort to a Great Plains farmer who has seen the seed blown out of the ground by the wind and has had his fertile soil blown into drifts by the wind, or entirely removed.

The following is an extract from an article for the 1935 Department of Agriculture Yearbook, prepared by the Forest Service:

> Soil erosion by wind has been more destructive throughout the Great Plains region during 1933 and 1934 than for any other similar period since the native sod was broken for crop production. Millions of acres are subject to wind erosion, and from hundreds of thousands of acres of level to slightly rolling land the soil was blown as deep as the fields had been tilled the previous year. Fences, Russian thistles, weeds, shrubs, farm machinery in the fields, farmsteads, windbreaks, roads, or any obstruction that might retard the wind velocity and permit the soil to settle were filled or covered with wind-blown soil.
>
> The principal causes of the disastrous soil blowing in 1933 and 1934 were continuous high winds, intensive cultivation, the practice of burning stubble, low rainfall, and lack of organic matter to hold the soil in place. The loam and light sandy soils are subject to blowing. Under the same conditions the light, sandy soils will usually blow before the heavier loams.
>
> The first sign of soil blowing is a little dust arising from a small portion of the field. Later the dust will come from a larger area, and if control measures are not begun promptly, all the field will eventually be blowing.

During the period under consideration there were 5 major dust storms, considering only those that overspread a considerable section of the country. In addition, there were many that were confined to a rather limited portion of the Great Plains and adjacent sections.

The first great storm occurred on November 12–13, 1933, when dust was reported from Nebraska to Georgia and New York. The second of these was on April 9–12, 1934, with dust noted from the Dakotas to Florida. The third followed soon after on the 18–20th of the same month, with dusty conditions ranging from the Dakotas southeastward to western North Carolina. The fourth major storm was on April 21–24, 1934, when dust was noted from the Dakotas to eastern Tennessee. The next was the most widespread of them all, occurring on May 9–12, with dusty conditions reported from all sections east of the Great Plains, except along the Gulf coast and in Florida.

During November 1933 there were 38 reports from first order Weather Bureau stations of dusty conditions; during December only 1, January 10, February 25, March 18, April 179, and May 182. The storms during May were largely confined to 4 or 5 days around the 11th, but during April they were more general, with dust noted in some part of the country on all but 4 days of the month.

The following are extracts from reports furnished by the section directors of the Weather Bureau in the States most seriously affected.

Huron, S. Dak.—The number of days with dust storms that involved practically the entire State was 60 for the 5-month period, January to May, 1934. Agriculture, of course, has sustained the greatest losses. In the eastern half of the State, where small grain cultivation predominates, every farm has been injured, more or less, by soil erosion, destruction of fences, injury to buildings, loss of crops, and the depletion of herds and other stock. The total losses to agriculture, transportation, and business, is estimated at 200 million dollars. April 18–23. Dust storms continued to prevail with great severity. (See fig. 1.) Farm work at a standstill, agriculture demoralized by continued drought and almost daily occurrence of dusty weather and blowing of soil. Enormous losses to winter grains and early seeded crops. The storm of the 21st was so severe that darkness came on at 4:36 p. m. and continued until 5:56 p. m. during which time lights were required. Visibility was reduced to only 50 feet.

Bismarck, N. Dak.—While frequent dust storms have visited North Dakota this spring (1934), those on 11 days warrant special mention. The most severe of these storms occurred on April 21 and 22. The velocity of the wind was greater on the 21st, but the volume and density of the dust was greater on the 22d. The latter storm caused the most comment because of the fact that the 22d fell on a Sunday, and travel both by automobile and by plane was hazardous and difficult. Several aviators reported that dust was encountered at all levels up to 14,000 feet. A report on the storm of April 22 follows: A severe dust storm began at 11 a. m. and continued all day, ending the night following. Visibility at the station was as low as 200 yards, at various times. This was the most severe dust storm experienced at the Bismarck station during the 28 years that I have been in charge.

Lincoln, Nebr.—The presence of dust in the air is not rare in Nebraska, especially during dry periods in February, March, and April. During the present season (1934) the dust storms have been more numerous than usual, more general in character, and have extended into May, which ordinarily, except for June, is the wettest month of the year. Dust was recorded during March somewhere in the State on 11 different days, and on two separate occasions, the 13th and the 16–17th, was general and severe, obscuring the sun at times. During April, dust occurred on 21 days, and on the 10–11th it was dense enough to obscure objects at a distance of 1,000 feet in many places.

Topeka, Kans.—At Topeka the dust storms of April 11 and 23, 1934, were the worst in many years. On these days the sun was obscured at times by dust and in the evenings illumination from street lights was materially dimmed. It would seem that these dust storms (a kind not at all uncommon in western Kansas during prolonged dry periods, especially in spring when wind movement is high) were largely of local origin in that section; and in eastern Kansas caused by strong northwest winds carrying dust from States to the northwest.

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Minneapolis, Minn.—Following the great dust storm of November 12, 1933, over the Plains States and territory eastward, there were no such storms of importance in Minnesota until the latter half of January 1934. During the last decade of January unusually high winds prevailed and thick dust occurred on the 22d, 23d, 24th, 28th, and 31st. Thick dust occurred on six dates in February in southern counties. Unusually dry, windy weather during most of March favored dust storms which were of frequent occurrence. Thick dust occurred on 15 dates in southern and western counties. Weather conditions during April greatly favored dust storms, with unusually dry, windy weather prevailing during most of the month. Soil moisture was rapidly depleted, much new seeding was blown out of the ground, soil from plowed fields drifted badly, and considerable damage to growing crops resulted. Thick dust occurred on 19 dates. Unprecedentedly dry weather in May combined with frequent high winds greatly favored dust storms. Thick dust occurred on 8 days over the entire State. The climax of the dust storms prevalent so far this year was reached on May 9–10. Reports from over the State indicate that this storm was probably the most severe of its kind ever experienced. Much seed was uncovered or blown out, especially on light soils, where in extreme cases as much as 90 percent was reported lost.

Des Moines, Iowa.—November 12, 1933. This was probably the worst and most general dust storm in recent years and, according to the opinions of many, the worst dust storm ever to occur in Iowa. The air was not only filled with fine dust, but with debris of various kinds. At times objects could not be distinguished at a distance greater than 50 feet. This gale caused loss of lives and considerable destruction of property. Dust storms that began on the 18th continued until a wide-spread general storm occurred on the 23d.

St. Louis, Mo.—The term "dust storm" is entirely applicable to the conditions on November 12–13, 1933, April 10–11, April 22–24, and May 10–11, 1934, on account not only of the unusual thickness of the dust, but the brisk winds on those dates, which carried it to practically all parts of the State. Probably the dust storm of May 10–11 was the most severe, considering Missouri as a whole, but in some sections that of April 11, or April 23, was considered worse.

Milwaukee, Wis.—Dust reported on about 19 dates previous to May 1934. The worst dust storm of which there is any recollection in Wisconsin occurred on May 9–10, and covered the entire State. There were fresh to strong winds which drifted the soil in the fields and in places uncovered newly sown grains. By the morning of the 10th dense dust clouds covered the sky and this condition continued all day.

Some extracts from the station records show the progress of the May 9–12, 1934, dust storm eastward.

Madison, Wis.—The dust began to appear in the sky about 6:30 p. m., E. S. T., on May 9, and continued until after dark on the night of May 10–11.

Dubuque, Iowa.—Light dust began at 10:30 p. m. and continued until 9:30 a. m., May 11. Dense dust began at 11 p. m., May 9, and ended during the night of May 10. The minimum visibility was 800 feet.

Keokuk, Iowa.—A dust storm began in the afternoon of May 9 and continued through the 10th, 11th, and 12th. Visibility on the 10th was limited from 11 blocks to 2½ miles.

Columbia, Mo.—The air was quite murky on the 10th.

Buffalo, N. Y.—Dust was first noted at Buffalo Airport at the noon observation of May 10, 1934, due to the discoloration of a sprinkling rain which occurred at that time. The visibility was 5 miles. From this time on dust of light intensity was recorded until 2 a. m. of May 11. The visibility was from 1½ miles to 5 miles during this period.

Pittsburgh, Pa.—The dust storm that was reported at several Western stations on the morning of May 10, 1934, was first observed in the vicinity of Pittsburgh as a peculiar pale yellow haze in the upper air about 6:15 p. m. of the 10th. At the airport station the dust was most dense at the 6 and 7 a. m. observations on the 11th when the visibility was reduced to 1 mile.

Cincinnati, Ohio.—First evidence of the Western dust storm reached Cincinnati shortly after noon on May 10. It was first observed on the hilltops at about 12:15 p. m., and at the Lunken Airport at 12:30 p. m. Visibility was greatly reduced, being only three-fourths of a mile from 2:30 p. m. to after 3 p. m.

Nashville, Tenn.—Visibility was less than 1 mile during the evening of the 10th and until 9 a. m. of the 11th at Nashville, and only one-fifth to one-fourth of a mile when the dust first appeared around 7 p. m. of the 10th.

Springfield, Mo.—Dust was reported on May 10. Visibility was reduced to one-half of a mile at times.

Portland, Maine.—The dust storm affected this vicinity on May 11, 1934, from 9:30 a. m. to 5:30 p. m. It began quite suddenly when the wind shifted from south to west and ended when the winds became west-northwest, shifting to northwest. Visibility was 1 mile at 2 p. m.

Boston, Mass.—A veil of dust appeared in the air shortly after day break on May 11 in New England and undoubtedly moved eastward over the ocean during that day. The dust was so fine that it appeared much as a high haze and was at an elevation of some 500 feet or more where visibility was reduced to a fraction of a mile, whereas visibility on the ground was up to 2 miles.

New Haven, Conn.—The sky became covered with dust at 9:30 a. m., May 11, which moved from the west and continued until shortly after 6 p. m. It was densest from 1 to 3 p. m. and reached close to the ground between these hours.

Baltimore, Md.—The dust was in the lower and upper atmosphere, within 2 to 3 miles of the earth's surface. In the lower atmosphere the density thickened after 8 a. m., May 11, at which time visibility was between 6 and 8 miles, decreasing to 1 and 2 miles between 10:30 a. m. and 2:30 p. m.

Raleigh, N. C.—Dust was first observed here at 2:40 p. m. on the 11th. Overhead there was only a hazy appearance, dust being observed mainly in looking toward the horizon. Dust seems to have disappeared or gradually withdrawn from most of the Piedmont on the 12th, but continued in the mountain region until the 14th.

Atlanta, Ga.—The second instance (referring to the dust storm of November 13, 1933) was observed in Georgia on May 11 and 12, 1934. In extreme northern Georgia the brightness of the sun was much reduced and mountains 10 miles away were cut off from view. In Atlanta the sky had a whitish appearance on the 12th.

Vicksburg, Miss.—May 11. Sun set yellow due to dust. Visibility 2½ miles in the west. Continued until 9 a. m. of the 13th.

Charleston, S. C.—Southerly winds on May 10 and 11 prevented the dust in the air over the central sections of the country from reaching this station, but on the 12th there was a sudden shift to northerly at 4:20 a. m. By 5:45 a. m. our airport station was reporting dust, and dustiness increased until 7:40 a. m., when the visibility had decreased to 4 miles.

Savannah, Ga.—On May 12 a hazy appearance of the sky was observed after 10 a. m., evidently due to dust. This was more noticeable in the afternoon, when visibility

Photographs through courtesy of Mrs. M. C. Jorgenson, Watertown, S. Dak.

FIGURE 1.—Dust storms in South Dakota, April 1934.

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was reduced to 5 miles. It seemed to disappear at nightfall and was not again observed.

These extracts from station reports are intended to show the approximate maximum spread of the dust from day to day. The stations were chosen at the eastern limits of the phenomenon on the dates reported.

After May 1934 the extremely dry conditions that made such widespread dust storms possible began to be alleviated to some extent. Moderate to fairly generous rains were rather general over much of the region covered by the dry condition of the soil and, even where they were not sufficient to break the drought in a real sense, they were sufficiently heavy to lay the dust in many places and thus tended to a more stable soil condition.

After May, while there were some dust storms, they were mostly moderate in character and were more or less local in extent. The reports of the various sections, as rendered to the Central Office, carry very few references to dust storms.

As a postscript to the above, it is interesting to note that the region mentioned as extremely dry in January continued so until the first of March, with severe dust storms reported throughout. The dust storms were rather widespread within the dry sections and became increasingly frequent toward the last of February and the first of March. Finally, they were of such intensity that appreciable dust was reported as far east as the Atlantic coast on March 6 or 7.

EFFECTS OF LOCAL SMOKE ON THE CLIMATE OF NASHVILLE, TENN.

By FOSTER V. JONES

[Weather Bureau, Nashville, Tenn., January 1935]

Few cities in the United States have a greater smoke nuisance to contend with during the winter months than Nashville, Tenn. Frequently during this season, dense smoke extending about 250 feet in height blankets the downtown section of the city for approximately a 4-mile radius from the Weather Bureau office. It has been so dense on occasions that the visibility was reduced to zero, the sun's disk invisible from street level, and street and automobile lights kept burning until after 10 a. m., although at the same time just outside the smoke area the sky and air were brilliantly clear.

The formation of this smoke shroud over the city is directly dependent on meteorological conditions, which when combined with local geographical features form a perfect union for stagnation of the lower atmosphere. Nashville is situated in a bowl completely surrounded by a rim of hills 300 or more feet high, and traversed diagonally by the Cumberland River. It has been observed that the smoke does not form when the wind velocity, as measured by the Weather Bureau anemometer 188 feet above the ground, exceeds 8 miles per hour. Velocities lower than 8 miles generally occur when a slow moving southeastern HIGH overspreads Tennessee, at which time the wind lulls and the temperature falls rapidly to a critical point.

The only available records of the density of smoke at Nashville were made by R. M. Williamson during the several winters beginning 1927–28. The results were included in a paper read before the Tennessee Academy of Science and published later in the Journal of the Tennessee Academy of Science.[1] Williamson's statement in part is as follows:

> The observations were made from the Weather Bureau office, in the Stahlman Building, and concerned the density of smoke as observed from that point, and at the hours 7 a. m., 9 a. m., 12 noon, and 4 p. m. Records were made during February and March each 4 years, December and January each 3 years, and November 2 years. Density was graded on the Ringelmann scale, as published and used by the United States Geological Survey. * * * The following table gives the monthly averages for the 4 winters at the hours specified.

Month	7 a. m.	9 a. m.	12 noon	4 p. m.
November	2.0	1.5	1.0	1.2
December	2.3	2.1	1.5	1.4
January	2.1	1.9	1.5	1.2
February	2.1	1.8	1.2	1.1
March	1.3	1.0	0.4	0.2
Winter	2.0	1.7	1.1	1.0

> The percentages for the winter were, respectively, 40, 34, 22, 20. These figures indicate the much greater prevalence of smoke in the early morning hours than in the afternoon. They show a gradual diminution of smoke from a maximum at about 7 a. m. to a minimum about the middle of the afternoon. This corresponds in a general way to the diurnal march of average wind velocity, for smokiness and wind velocity are very closely related. The density of smoke is, as a rule, in inverse proportion to the velocity of wind. It is least dense in the afternoon, at which time average wind velocities are highest. It is most dense in the early morning, for then the atmosphere is in its most quiescent state, unless, of course, there is active storm movement. Smoke will clear away often during times of rapidly rising temperature, due to turbulence in the atmosphere created by rising currents. The smoke is then lifted to elevations where it is carried away by the upper horizontal currents, while at the surface there may still be but little lateral movement. The presence of smoke in varying degree in different parts of the city, while dependent to some extent upon the number and size of the chimneys from which it comes, is also dependent upon the direction of the wind at the time. The detailed records show that there was some smoke nearly every day in the winter months, although there were several periods of 3 or 4 consecutive days when none was observed.

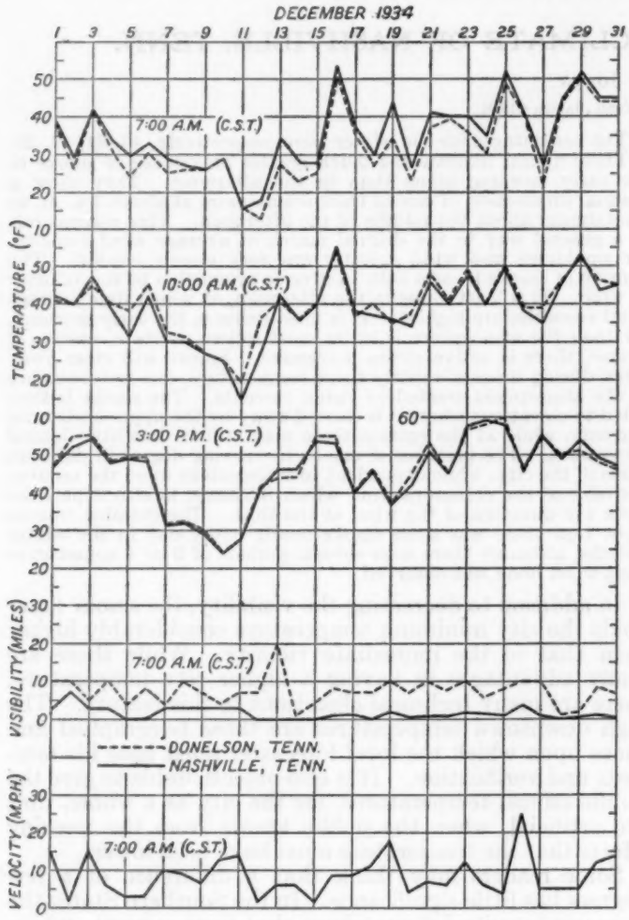
In addition to decreasing the visibility, the smoke layer holds the city minimum temperature considerably higher than that of the immediate vicinity. While there are many advantages in having a higher city temperature, there are many technical objections to this feature. The high downtown temperatures are those telegraphed and those upon which the local forecaster must base his forecasts and verification. It is also objectionable to give the public official temperatures, for the city as a whole, that are artificial, when the public knows from the freezing effects that the temperature must have been lower.

Some readers may think that a difference of a few degrees has little significance. In the Southern States the situation is quite different from that farther north, where freezes are almost a daily occurrence. Southern homes are not built to stand long spells of severe winter weather. Produce dealers often leave carloads of perishable goods unprotected. Farmers depend on temperatures near freezing for the killing of their winter meat supply. Therefore, a very definite critical temperature is reached at 32°, and continues down to 10°. These few degrees mean profit or loss and should be forecast as accurately as possible.

The attached graphs of the temperature, visibility, and wind velocity show the difference during the month of December 1934. There was no particular reason for choosing the month of December 1934, except that the data were more readily available and the work could be done from day to day; thus we have an arbitrary period in which typical effects are represented, although differences at this season are not nearly of so great a commercial

[1] Williamson, R. M.—Visibility, A New Element in Meteorological Observation. (Read before the Tennessee Academy of Science, Nov. 26, 1932, and published in the Journal of that society.)

value as those of early spring and late fall. The records are from the temperatures taken at the Nashville Weather Bureau located in the heart of the city, and the Airways Radio Station located at Donelson, 10 miles east of the Weather Bureau. The thermometers at Nashville are 168 feet above the ground—653 feet above m. s. l., and those at Donelson 5 feet above the ground—625 feet above m. s. l.; thus the instruments are nearly in the same plane. A partial record was kept at the writer's residence 3½ miles northeast of the city office, 500 feet above m. s. l. but beyond the rim of hills and the smoke blanket. The temperature and visibility were found to be in close agreement with that of Donelson, with a tendency to slightly



lower, however; this was attributed to the more open exposure of the thermometer.

On the graphs the most typical smoke condition is noted on the fifth. A mass of polar air had overspread the State, the sky was clear and the air transparent. The visibility was reduced to zero at Nashville and to 4 miles at Donelson at 7 a. m. The low visibility at Donelson was the result of a light fog along Stones River, which runs in a valley 1 mile east of the station, in combination with the settling of the smoke particles carried by the eastward drift of the intermediate atmosphere from the city of Nashville. After 7 a. m. the city usually begins "firing-up" in earnest, and this morning was not an exception. Automobile and street lights were necessary until 10 a. m., and the sun's disk was not visible from the street at intervals, but was always visible from the Weather Bureau office on the twelfth floor of an office building. The temperature remained nearly stationary within the city until the smoke had absorbed enough of the sun's radiation for the mass to become warmer than the surrounding air and ascend to heights where the wind was sufficient to carry it away. This was about 10 a. m. During this interval Donelson's temperature had risen from 6° below that of Nashville to a point 6° above. However, as soon as good circulation began the temperatures became equalized, as is shown by the graph as of 3 p. m.

A like condition is shown on the 12th; in this case the temperature at Donelson rose from a point 5° below that of Nashville to 9° above, or an increase of 23°, while Nashville was gaining 9°. It must be remembered that the Nashville temperatures are taken 168 feet above the surface, which is often near the top of the smoke layer, and the conditions would be magnified at street level. As previously stated, the main commercial interest is in temperatures that are lower than those of the city; and as can be observed from the graphs, conditions are reversed before and after sunrise; i. e., before sun-up the smoke prevents surface cooling by radiation, and after sunrise acts as an insulator between the sun and the surface.

During the month of October 1934 there were three periods of large differences in temperature between the city and the suburbs. On the mornings of the 14th and 26th, light frosts were observed in the suburbs, when the city minimum temperatures were 46° and 49°, respectively. During the period October 28–30, a large mass of Arctic air overspread the southeast. The atmosphere was transparent and the sky clear, but a thick smoke blanketed the city on all three mornings. The city temperatures were 36°, 35°, and 39°. During this time ice was noticed in all the suburbs and on the morning of the 29th was about one-fourth of an inch in thickness. There were some reports of automobile radiators freezing; there were no suburban temperatures kept at the time, so it is impossible to state the exact minimum reached, but from the freezing effects, which killed vegetation, temperatures must have been below freezing to a considerable extent, and those of the immediate downtown section kept up because of the smoke layer.

On the morning of January 3, 1935, the temperatures at Nashville was 35° (3° above freezing), and at Donelson 23°, or 9° below freezing; at the same time the temperature within the suburbs was 24°. Smoke over the city was very dense, making lights necessary, but it was estimated to extend only a few feet above the Weather Bureau roof. Visibility was practically unlimited beyond the city.

Comparative averages, winter of 1933–34

MEAN TEMPERATURE, °F.

	December 1933		January 1934		February 1934		March 1934	
	7 a. m.	10 a. m.	7 a. m.	10 a. m.	7 a. m.	10 a. m.	7 a. m.	10 a. m.
Nashville	44.4	48.2	37.9	40.6	29.9	35.0	40.8	45.6
Donelson	41.9	48.4	36.3	42.0	27.7	36.0	38.7	47.6

VISIBILITY, IN MILES

Nashville	0.6	[1] 3	0.3	[1] 6	0.6	[1] 3	0.6	[1] 6
Donelson	5	5	5	5	4	5	6	7

[1] At noon.

Highway contractors appreciate accurate temperatures near the surface when laying concrete and more especially certain forms of asphalt which cannot be laid when the temperature is less than 45°. Frost conditions are of

FIGURE 1.—Artificial light pillars.

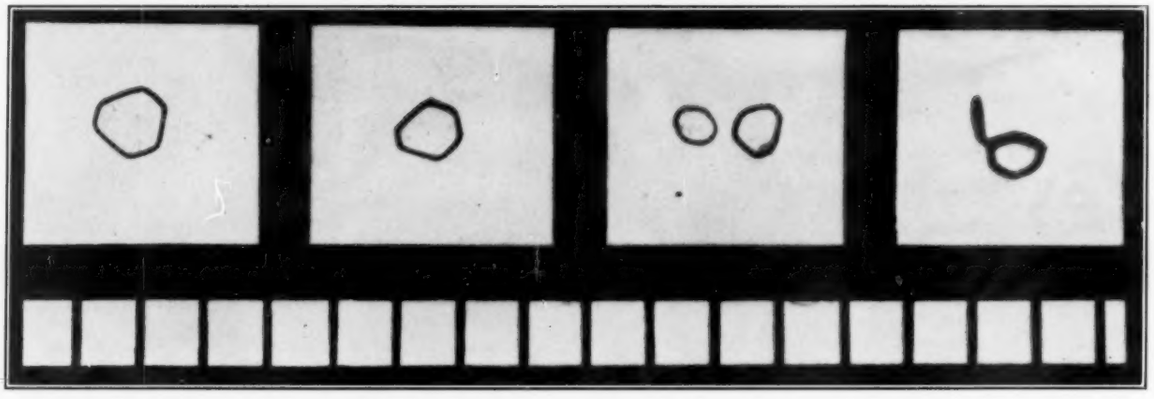


FIGURE 2.—Typical crystals.

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the utmost importance at certain seasons and forecasts cannot be accurately made from city temperatures thus affected. Shippers' forecasts should cover the terrain over which the shipment is transported, and should be verified from country and not city temperatures.

Visibility from a city office is like the proverbial "drop in a bucket" insofar as the surrounding country is concerned. From the aeronautical standpoint, it is of little value; in view of the present trend of aircraft, it may be some time before we land in the heart of cities to any great extent. Certainly this visibility cannot be used to determine questionable air masses.

Although only a few instances have been cited and the length of comparative records is short, it can be readily seen that smoke has a definite influence on the climatic features of Nashville. A similar problem will be found in a large number of our Southern cities and presents an item for further investigation.

ICE CRYSTALS AND HALO PHENOMENA

By B. W. CURRIE

[University of Saskatchewan, Saskatoon, Saskatchewan, Canada, March 1935]

Vertical pillars of light frequently are seen during the winter months above street lights, electric advertising signs, and airport beacons in Western Canadian cities.[1] These pillars are caused by reflection of light to the observer from falling ice crystals between him and the light source. Essentially this is a halo phenomenon, and one for which the form and the size of the ice crystals, and the accompanying atmospheric conditions, can be observed.

The color of the light from the pillars, and its state of polarization, show that they are caused by reflection. The color of each pillar is exactly the same as that of the light below it; the red pillars from the neon electric signs are particularly noticeable. The light from the pillars due to distant street lights shows no polarization, while the light from the top of the pillars produced by near street lights shows polarization in a vertical plane. Evidently, if the observer is close enough to a street light, a portion of the light forming the top of the pillar is reflected from the ice crystals at angles close to the polarizing angle.

Figure 1 shows an artificial light display. The apparent height of a pillar increases with the intensity of the light source. Calculations based on known distances to light sources and the measured sizes of the corresponding pillars on photographs often give heights in excess of 1,100 feet. When the wind velocity is greater than 8 to 12 miles per hour, only the brightest lights have pillars, and these are always low and faint.

Whenever the pillars are seen, the falling ice crystals are caught on a glass plate and photographed by transmitted light, a 1-inch microscope objective being used for a photographic lens. In this way images of 40 to 70 crystals are obtained by a single exposure, and these may be examined and measured later. Two kinds of crystals—thin hexagonal plates and thin broken fragments of snowflakes—cause the pillars. Only the first kind is found on calm nights when the most brilliant displays occur. Figure 2 shows several typical crystals. A tenth-millimeter scale magnified the same as the crystals indicates their size. The mean maximum distance between opposite sides of 61 crystals photographed at Saskatoon, Canada, on the evening of January 23, 1935, was 0.071 mm. Individual values ranged from 0.14 to 0.03 mm. Occasionally two crystals will freeze together (as shown in figure 2), and the thickness can be measured. The mean thickness of 18 crystals was 0.016 mm, extreme values ranging from 0.025 to 0.01 mm. Rounding of the edges due to melting will tend to make this value too large.

Both kinds of crystals may be found when the pillars are seen on windy nights. However, the second kind alone can cause the pillars. They are snowflakes broken by the wind, and are of many shapes and sizes; diameters below 1 mm predominate. Incidentally, pillars have never been observed when unbroken snowflakes are falling.

Hexagonal plates more than 0.1 mm across have been observed so far only once. This was on November 18, 1932, at the Canadian International Polar Year station near Chesterfield Inlet, when a brilliant pillar was seen above a light outside the Roman Catholic Mission Hospital. The mean diameter of the plates was 0.14 mm; extreme sizes ranged up to 0.8 mm. This was the only time during the year at Chesterfield that an artificial light pillar was observed, and was also the only time when an observed crystal fall consisted of plates alone. Generally the falls were a mixture of plates, needles, combinations of the two, and needles with pyramidal ends.

Observations show that the crystals which cause the artificial light pillars are also responsible for solar and lunar pillars, and 22° halos. If the moon is visible at the time of an artificial light pillar display, a faint pillar extending above and below the moon can be seen. A solar 22° halo and pillar were observed simultaneously at the secondary auroral station, 20 miles south of Chesterfield, on January 24, 1933. A 15- to 20-mile wind was sweeping the crystal cloud along the earth's surface, and the sun was just above the horizon. The upper portion of the 22° halo was seen as a circle projected on the sky, and the lower portion as a parabola projected on the earth's surface. The pillar above the sun was faint, and may have extended below the sun, but it could not be distinguished from the light reflected from the snow surface. Incidentally a distinct difference exists between the parabola[2] observed in this case and that frequently seen from frost formations or crystals on the earth's surface, the illumination inside the parabola being much brighter because of the light reflected from the snow surface. The crystals were found to be mostly thin plates when examined by the lens on the auroral camera (the only lens available). Their size was considerably less than 1 mm.

Weather conditions during artificial light displays vary greatly. Wind velocities less than 8 miles per hour seem essential to the formation of bright pillars. If snow is falling, the pillars can be seen only if the wind is strong enough to break the snowflakes. Temperature conditions show no uniformity, partly because the crystals are formed at higher levels and then fall to the surface. The temperature changes leading up to the two displays already mentioned contrast sharply with each other. At Chesterfield the temperature dropped 10.8° F. between 14 : 50 h.

[1] Nature, 1930, vol. 125, p. 526.

[2] Die Haloerscheinungen, by R. Meyer, pp. 73–74.

and 20:00 h. L. M. T. and the relative humidity increased to 100 percent, remaining at that value during the display. At Saskatoon the temperature rose 28.5° F. between 06:00 h. and 20:00 h. L. M. T., and the relative humidity remained constant at about 100 percent. In the latter case warm, moist air was coming in, raising the air temperature, but was kept cooled to the dew point by the relatively cold snow surface. During the first display the mean temperature was 5.4° F., and during the second −12.0° F. Observations taken so far show that the smaller crystals are formed at the lower temperatures.

It seems reasonable to assume that more complex halos are formed around artificial lights, but that they cannot be seen because of the general illumination. If a strong source of light could be placed far from other light sources many of the usual halo formations might be seen, and the crystals and atmospheric conditions causing them could be studied.

FLOODS, EARTH AND SNOW SLIDES, AND AN ICE STORM, FROM UNPRECEDENTED PRECIPITATION IN THE STATE OF WASHINGTON, JANUARY 1935

By LAWRENCE C. FISHER

[Weather Bureau, Seattle, Wash., February 1935]

All previous-recorded 24-hour and 5-day amounts of precipitation in the State of Washington were exceeded during a period which began with snow on January 21, 1935; and station records were broken for a number of places in northern Washington. In the western part of the State the snow turned to rain on the 21st or early on the 22d; rain followed in the colder eastern part of the State to a considerable elevation in the mountains. To the west and south of the Olympic Mountains, which are in extreme northwestern Washington, the following precipitation amounts were recorded: At Quinault, 12.00 inches on the 21st (mostly rain) and 37.00 inches in the 5-day period beginning that day; Elkpark, 12.00 inches in 26 hours—the 5-day period was incomplete; Spruce, 11.59 inches on the 21st, and 29.92 inches in the five days; Wynoochee Oxbow, 9.47 inches on the 21st and 29.91 inches in the five days. Previously the greatest 24-hour amount in the State was 8.16 inches. The total for January, 50.39 inches, is the greatest ever recorded in any month at Quinault. However, this amount has been exceeded at other stations in the State, notably by the 57.04 inches at Cougar for December 1933. East of the Cascade Range, in western Okanogan and northern Chelan Counties, the fresh fall of snow on the 21st was remarkable: At Winthrop, 52 inches; Gunn Ranch, 48; Stehekin, 44; and Stockdill Ranch, 40. The 52 inches of freshly fallen snow at Winthrop is the greatest record in Washington. It reduced to 4.16 inches of water.

Prior to the 21st, cold air under high pressure had spread from Alaska to the Pacific Northwest, while a barometric depression developed marked intensity off the coast. At the time of this precipitation the principal path of the warm moist air from the ocean which flowed over the cold air, was across southern British Columbia and northern Washington. Excessive rains and melting snows made rushing torrents of the rivers in the hills and mountains of the northwestern counties, and the lowlands were flooded. Floods in the northeastern part of the State, however, were not serious, except in a few localities. Landslides occurred in many places where highways and streets had been graded, and on barren steep slopes. A number of snow slides were reported in the mountains. A 260 square mile sector of northwestern Whatcom County was visited by a very destructive ice or glaze storm, locally called a "silver thaw." This ice storm extended into Washington from British Columbia, and was caused by rain falling into a stream of cold air which was flowing down the Fraser River Valley from the very cold interior of British Columbia and (a part of it) into Whatcom County. It crossed the border in the region about Sumas moving west-southwest, missing Blaine on the north and Bellingham on the south. No temperature readings were made at Clearbrook from the 22d to the 24th, as the thermometer shelter was sealed by a coating of ice.

As a result of the severe weather conditions, four persons lost their lives. A man was buried in a snowslide in eastern Whatcom County, another was asphyxiated while keeping warm in his auto when entrapped between two snowslides in Snoqualmie Pass, and a woman and child were drowned near Burlington.

The total property loss, undoubtedly exceeding $1,500,000, was greatest in the northwestern counties. The things damaged or destroyed included bridges, highways, pavements, bulkheads, sewers, homes and furnishings, farm buildings and contents, hay, grain, farm implements, road equipment, cattle, horses, sheep, hogs, poultry, orchards, trees, shrubs, fall-sown grain, meadows, pastures, fences, telephone, telegraph, and electric light poles and wires. There also was erosion of farm lands, and deep deposits of silt, gravel, and debris; destruction of dikes, which permitted salt water to overflow fertile soil; interruption of transportation of passengers, mails, express, and freight; the local closing of schools, mills, logging and road camps; reduced production of dairy and poultry products, and local suspension of business.

JANUARY 1935, ABNORMALLY FOGGY AT BOISE, IDAHO

By H. G. CARTER
[Weather Bureau, Boise, Idaho, February 1935]

The average number of days with dense fog at Boise during the past 34 years has been 7 each year, occurring during the winter months. January 1935 will go on record as the foggiest January since the beginning of Weather Bureau records. There were 8 days on which dense fog was recorded during the month, followed by a dense fog on February 1.

During January 1935 dense fog prevailed 71 hours and 30 minutes, or 9.6 percent of the time. In addition to this dense fog, there were 54 hours and 20 minutes of light fog, making a total of 125 hours and 50 minutes (16.9 percent of the time) when either light or dense fog was recorded.

The period of record breaking foggy weather began at midnight of the 26–27th; and dense fog continued at frequent intervals until 8:15 a. m., February 1. During this period there were recorded 73 hours and 20 minutes (57 percent of the time) with dense fog, and 38 hours and 50 minutes (30 percent of the time) with light fog, making a total of 110 hours and 10 minutes when fog, either light or dense, was recorded. This was a total of 87 percent of the time.

The longest periods with continuous dense fog were as follows:

From 5:30 p. m. of the 29th to 11:30 a. m. of the 30th, 18 hours;
From 4:30 p. m. of the 30th to 8:30 a. m. of the 31st, 16 hours;
From 5:30 p. m. of the 31st to 8:15 a. m., of February 1, 14 hours and 45 minutes;
From 4:30 p. m. of the 28th to 7:15 a. m. of the 29th, 14 hours and 35 minutes;
From 10 p. m. of the 27th to 2 a. m. of the 28th, 4 hours.

From 9 p. m., January 25 to 9:30 p. m., February 6, there were a total of 169 hours and 45 minutes with light fog and 73 hours and 20 minutes with dense fog, making a total during slightly more than 12 days, of 243 hours and 5 minutes when either light or dense fog prevailed. This was 84 percent of the time.

During the periods of dense fog, from midnight of January 26–27 to 8:15 a. m., February 1, city traffic was considerably retarded; while minor collisions were frequent, no serious accidents were reported. Rail and airline schedules were disrupted, but no accidents occurred.

WEATHER OF ONE SEASON AS AN INDICATION OF THE WEATHER OF THE FOLLOWING SEASON, OR SEASONS, AT BOISE, IDAHO

By H. G. CARTER
[Weather Bureau, Boise, Idaho, January 1935]

There seems to be a firm belief in some localities that the weather of one season is a reliable indicator of the weather of the following season, or seasons.

On coming to Boise in the autumn of 1932 the writer was impressed with the frequent assertions of old residents that the weather of the coming season at Boise could be accurately foretold from the weather of the present season.

In order to check the accuracy of this popular belief, and to be prepared to intelligently answer queries pertaining thereto, a study was made of the Weather Bureau temperature and precipitation records for Boise, which began in 1868. The study was further stimulated by the importance of the fire-weather work in southern Idaho.

All seasons with plus temperature departures were classified as warm, all with minus departures as cold, all with plus precipitation departures as wet, and all with minus departures as dry, in every case disregarding the amount of the departure.

No conclusive evidence was found that the weather of one season was an indicator of the weather of the following season or seasons. In a few cases, however, there appeared to be some slight relation. The most marked instances are:

28 wet autumns were followed by 21 dry summers.
38 cold summers were followed by 27 dry springs.
28 wet winters were followed by 20 dry springs.
37 warm autumns were followed by 26 dry summers.

It was thought that an error might have been introduced by the disregard of the amounts of the departures. For example, a season with a plus temperature departure of 0.1° was placed in the warm column, although in reality the season was not what would be considered warm.

Tabulations were, therefore, again made, designating as warm or cold only such seasons as had a plus departure of 2° or more, and a minus departure of 2° or more, respectively. Seasons with precipitation of 50 percent of normal or less were classified as dry, and those with 150 percent of normal, or more, as wet. While this greatly reduced the number of seasons available for comparison, it was thought the larger departures would afford more reliable comparisons. A number of instances were found in which there appeared to be some relation. For example:

6 dry springs were followed by 5 dry summers.
8 wet springs were followed by 6 warm autumns.
12 warm summers were followed by 9 dry autumns.
12 warm summers were followed by 10 warm autumns.
12 warm summers were followed by 9 warm winters.
16 cold summers were followed by 12 dry winters.
15 wet autumns were followed by 12 dry summers.
4 wet winters were followed by 3 dry springs.
4 wet winters were followed by 4 warm springs.
4 wet winters were followed by 3 dry summers.
4 wet winters were followed by 3 wet autumns.
4 wet winters were followed by 3 warm autumns.

Seasons with marked departures may give some indication of future weather, but in most cases it is too uncertain to be used as the basis for long-range forecasts.

SOME PROBLEMS OF MODERN METEOROLOGY

[Review]

Beginning with July 1930, a series of articles, each giving a critical inventory of our knowledge of some special branch of meteorology, has been running in the *Quarterly Journal of the Royal Meteorological Society*. This series, just completed, has been assembled, with a few notes that bring the articles to date, in book form, octavo, 170 pages, and made available at moderate cost. The subjects discussed and their importance are best indicated, perhaps, by the table of contents, herewith, and the introduction, next quoted, by D. Brunt:

1. The Present Position of Theories of the Origin of Cyclonic Depressions, by D. Brunt.
2. The Present Position of Theories of the Circulation of the Atmosphere, by E. W. Barlow.
3. The Present Position of Theories of the Electricity of Thunderstorms, by R. A. Watson Watt.
4. The Present Position of Weather Forecasting, by C. K. M. Douglas.
5. The Present Position of the Theory of Turbulent Motion in the Atmosphere, by E. Ll. Davies and O. G. Sutton.
6. The Present Position of Seasonal Weather Forecasting, by C. W. B. Normand.
7. Radiation and Absorption in the Atmosphere, by D. Brunt.
8. Problems of Antarctic Meteorology, by E. Kidson.
9. The Origin of Anticyclones, by C. E. P. Brooks.
10. Terrestrial Magnetism—the Magnetic Variations of Short duration, by A. H. R. Goldie.
11. Meteorological Acoustics, by W. S. Tucker.
12. The Transformations of Energy in the Atmosphere, by D. Brunt.
13. The Condensation of Water in the Atmosphere, by M. G. Bennett.
14. The Problem of Rainfall, by C. K. M. Douglas.
15. Atmospheric Ozone and Meteorology, by G. M. B. Dobson and A. R. Meetham.
16. Post-glacial Climates and the Forests of Europe, by C. E. P. Brooks.

When in 1930 the Council of the Royal Meteorological Society invited me to take over the duties of editor of the society's publications, it occurred to me that a series of articles dealing with the problems of modern meteorology would serve a useful purpose in the present stage of the development of the science. The idea was suggested by my recollection of an excellent series of articles on the problems of astronomy which was published in the *Observatory* some 20 years ago, and there seemed to be every reason to suppose that a similar series of articles dealing with meteorological problems would be of interest to readers of the *Quarterly Journal*. The aim of these articles, which are now reproduced collectively in this volume, was to give summaries of certain aspects of meteorology in the form of critical discussions of existing theories, rather than to advocate new theories. To some extent the project was regarded as an attempt to take stock of our present knowledge, to find how much of modern meteorological theory is generally agreed upon, or failing this, to attain some agreement as to what we do not know. The 16 papers which follow do not by any means exhaust the problems of modern meteorology; but many of the problems of the atmosphere are unfortunately not sufficiently clear even to permit of definite formulation.

A tthe present time it appears to be particularly desirable to take stock of our knowledge of atmospheric processes. The acceleration in the rate of publication of papers on the subject has been so great in the last few years that it is difficult to visualize what has been the net gain since the birth of scientific meteorology. The main difficulty to be faced in planning such a stock-taking, indeed the main difficulty in planning any coherent treatment of meteorology, whether in the form of a textbook or otherwise, is the absence of a central connecting thread in the form of a clear-cut theory of the circulation of the atmosphere. In the absence of such a central thread it is not possible to decide finally what is essential, and what is of only temporary interest. It is hoped that the series of articles now reprinted will be of interest, not only to the meteorologist, but also to others who desire to know something of the present state of meteorology.

Advantage was taken of the opportunity offered by the reprinting of the series to add brief notes supplementing the original articles where that seemed desirable, and the author was readily accessible. These additional notes are given at the end of the volume. They are mainly brief references to additional papers which were not mentioned in the original articles, and it is unfortunately not possible to say that any of the problems have been solved since they were formulated.

Meteorology is essentially an observational science. Since it is not possible to control atmospheric conditions, all that the meteorologist can do is to observe all the salient factors in the greatest possible detail. But difficulties arise when any attempt is made to define what are the salient factors. We may adopt as a truism the maxim that "the same causes will always produce the same effects", but in meteorology we can only adopt with reservations the maxim that "like causes will produce like effects." The latter maxim is only true when small variations in the initial conditions produce only small variations in the final state of the system. Clerk Maxwell pointed out in "Matter and Motion" that while this condition is satisfied in a great many physical phenomena, there are other cases in which a small variation in the initial conditions may produce a very great change in the final state of the system, much as the displacement of the points on a railway may cause a train to run into another, instead of keeping to its proper course. At the end of the paragraph in which Maxwell discussed these principles, Larmor appended a note that "the observable regularities of nature belong to statistical molecular phenomena which have settled down to permanent stable conditions. Insofar as the weather may be due to an unlimited assemblage of local instabilities, it may not be amenable to a finite scheme of law at all."

To apply these considerations to the domain of meteorology leads at once to two questions: (1) If the observed surface distributions of pressure, temperature and humidity, as shown on the synoptic chart, are similar on two occasions, to what extent is the apparent similarity effectively modified by differences in the upper air? (2) If the conditions both in the upper air and at the ground are in the main similar on two occasions, will the small differences between the two occasions lead to small or large differences in the final developments?

There is little doubt that the answer to the first question is that conditions represented by similar synoptic charts of surface pressure may, and often do, develop into widely different conditions, so that the similarity of today's chart to some earlier one is not a safe guide for the forecaster. The cause of the dissimilarity in the later development in two such cases may possibly be dissimilarity of conditions in the upper air. Or it may be that the idea of similarity is based on a comparison of conditions over too small an area, and that a comparison over a wider area, notably if taken over a whole hemisphere, would show dissimilarities in the surrounding field. It would appear possible to investigate this question when the daily charts of the northern hemisphere, which are to be published for the period of the polar year, become available.

The answer to the second question cannot yet be given, since a sufficient number of observations in the upper air is never available. It is therefore never possible to state with complete confidence what are the conditions in the upper air on any one day, still less to compare these conditions on one day with those on another day. Upper air observations are only available in fair weather. In stormy weather they are usually very sparse, and it is not usually possible to state at all clearly the exact nature of the distribution of temperature or of wind in the upper air above a depression. For these reasons it is not possible to state how far initial small differences can lead to different conditions in the later development of two situations which initially show quite a marked resemblance.

The answer to the first question stated above is of far more than academic interest to the meteorologist. If indeed it were true that small initial differences can lead to great differences in the later development, then it is probable that no improvement in forecasting is to be looked for, beyond the slight improvements which will follow from the increase in the amount of information available, and increased rapidity of transmission, since it is not probable that a trigger action could be foretold with accuracy. If it may be assumed that small differences in initial conditions lead to only small differences in the final development, then it should be possible to develop a true science of forecasting, which can hope to trace out the course of the weather for more than a day in advance. At present, few British forecasters would care to issue forecasts for more than a day in advance as a daily routine. It is not, however, clear in what direction a further advance is to be looked for. The one outstanding new idea of the last 20 years is that associated in the minds of most meteorologists with the "polar front." The greatest achievement of this idea is the establishment of the fact that a cyclonic depression has a life cycle, not only in its lower levels, but also in the cirrus levels. The time is surely ripe for some new idea to be brought forward, and many young meteorologists are eagerly looking for a new method which may help to elucidate some of the puzzling features of the physics of the atmosphere. But it is not clear where the new idea is to come from. At the end of 1918

many meteorologists looked to an increase in the amount of upper-air data available, to help to solve their riddles. There has unquestionably been a considerable increase in the amount of upper-air data available every day, but it is doubtful whether they have proved as useful as was anticipated some 16 years ago. In practical forecasting the use which can be made of upper-air data is relatively small. At times an observation of temperature in the upper air may facilitate the forecasting of thunderstorms or of rainfall, but there are many days when the practical use made of the upper-air data is only slight. The present writer is well aware that some will differ from this view, but that others will undoubtedly agree. It may be that the advance for which we are looking will come from the application of thermodynamical reasoning to upper-air data, along the lines laid down by Shaw, Normand, Rossby, and Stuve, but at the moment it is not clear how far the methods of these workers can be of real use in day-to-day synoptic analysis.

There is a well-established fact which accounts for the difficulty of making fuller use of upper-air data, namely that such atmospheric features as cyclonic depressions, wedges of high pressure, and anticyclones, which travel from west to east, manifest themselves at low levels earlier than at high levels, to an observer at a fixed place.

One writer in a recent number of the *Quarterly Journal* expressed his belief that no obvious factor or line of attack could have escaped notice, in view of the large number of able young men now actively engaged in meteorological work. But it will be recalled that the ideas underlying the "polar front" methods were only very thinly disguised in Shaw and Lempfert's "Life-History of Surface Air Currents," and yet they did not attain full development until many years had elapsed. Many much older papers than that of Shaw and Lempfert may contain ideas which could now be elaborated with great profit in the light of our present knowledge of the physics of the atmosphere.

But whatever the future may bring, it is hoped that the statements of the present position with regard to certain aspects of meteorology which are contained in the series here reproduced may help to advance the science by clearing the ground of some obscurity, and helping to develop in the reader the right attitude of healthy sceptism.

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C. FITZHUGH TALMAN, *in charge of Library*

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING FEBRUARY 1935

IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January 1935, REVIEW, page 24.

Table 1 shows that solar radiation intensities averaged above normal for February at Washington and Madison and close to normal at Lincoln.

Table 2 shows in general an excess in the amount of total solar and sky radiation received on a horizontal surface on the Atlantic seaboard, the South and the far West, and a deficiency in the interior of this country and in Alaska. The regular publication of data from Cornell University begins with this issue. Some back data from this same station, and also from Mount Washington, are tabulated in table 2–A.

Table 3 shows low water-vapor content of the atmosphere on clear days at Washington with the exception of the 27th, when a sudden increase in water-vapor, markedly shown by the turbidity measurements, brought clouds at noon. There will be a short break in this type of measurement at Washington until the receipt and installation of a new multiple potentiometer, which, with other refinements in apparatus, should give better readings.

No polarization readings were obtained at Madison on account of continual snow and ice cover, and only one reading obtained at Washington—56 percent on the 18th. This is close to the November normal but considerably below the average maximum.

TABLE 1.—*Solar radiation intensities during February 1935*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance										
	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 1	1.19	.....	0.79	0.99	1.09	.....	.....	.....	.....	.....	1.02
Feb. 18	2.87	0.72	.83	.97	1.18	.....	.....	.....	.....	.....	2.74
Feb. 19	3.81	.....	.....	.....	.....	.....	1.35	.....	.....	.....	2.62
Feb. 21	1.68	.91	1.04	1.18	1.33	.....	.....	.....	.....	.....	2.13
Feb. 25	3.81	.....	.92	.....	.....	.....	.....	.....	.....	.....	4.57
Feb. 27	1.32	.75	1.04	1.06	1.36	1.66	1.38	1.16	.....	.....	1.24
Feb. 28	1.32	.....	.....	.....	.....	1.54	.....	.....	.....	.....	1.78
Means	.....	**.79**	**.92**	**1.05**	**1.24**	**(1.60)**	**(1.36)**	**(1.16)**	.....	.....	.....
Departures	.....	+.06	+.09	+.04	+.04	+.04	+.16	+.16	.....	.....	.....

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during February 1935*—Contd.

MADISON, WIS.

Date	Sun's zenith distance										
	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 19	3.15	.90	1.11	1.24	1.44	1.69	1.40	.....	.....	.....	2.87
Feb. 20	2.26	1.00	1.19	1.33	1.49	1.58	1.44	.....	.....	.....	1.68
Feb. 26	.74	.....	.....	1.33	1.49	1.62	1.52	.....	.....	.....	1.19
Feb. 27	.81	.....	.....	.....	.....	1.60	.....	.....	.....	.....	1.32
Feb. 28	2.24	.....	.....	1.28	.....	.....	.....	.....	.....	.....	1.78
Means	.....	(.95)	(1.15)	**1.30**	**1.47**	**1.62**	**1.44**	.....	.....	.....	.....
Departures	.....	+.02	+.07	+.10	+.11	+.04	+.08	.....	.....	.....	.....

LINCOLN, NEBR.

Feb. 1	3.15	.....	.....	.....	.....	.....	1.34	1.22	1.13	0.97	3.45
Feb. 2	2.74	0.83	1.03	1.17	1.48	.....	.....	.....	.....	.....	2.87
Feb. 4	3.15	.....	.....	.....	1.41	.....	1.39	1.19	.....	.....	3.15
Feb. 11	3.45	.85	.99	1.11	1.42	.....	1.40	1.22	1.08	.94	3.81
Feb. 12	3.98	.....	.82	.99	1.24	.....	.....	1.08	.95	.82	4.57
Feb. 19	4.16	.....	.....	.....	.....	.....	.....	.....	1.11	1.00	5.16
Feb. 20	2.49	1.04	1.12	1.24	1.42	.....	.....	.....	.....	.....	2.49
Feb. 21	3.81	.....	.....	.....	.....	.....	.....	.88	.68	.54	4.75
Feb. 25	1.12	.....	.....	.....	.....	.....	.....	1.27	1.16	1.02	1.07
Feb. 26	1.12	1.00	1.11	1.26	1.46	.....	1.45	1.23	1.15	1.04	3.45
Feb. 27	1.60	.96	1.07	1.24	1.43	.....	1.34	1.10	.96	.88	3.81
Means	.....	**.94**	**1.02**	**1.17**	**1.41**	.....	**1.38**	**1.15**	**1.03**	**.90**	.....
Departures	.....	+.01	+.01	−.01	+.04	.....	+.03	−.01	+.01	−.01	.....

BLUE HILL, MASS.

Feb. 1	0.6	.....	1.04	1.26	1.41	.....	1.45	1.34	1.17	.....	0.6
Feb. 6	.8	.....	1.09	1.21	1.29	.....	1.26	1.11	1.06	.....	.9
Feb. 7	1.0	.....	1.12	1.21	1.46	.....	1.44	1.31	1.20	1.10	.7
Feb. 11	2.4	.....	.....	1.15	1.30	.....	1.35	1.16	.....	.....	2.5
Feb. 12	1.0	.....	.....	1.23	1.44	.....	.....	.....	.....	.....	.6
Feb. 13	2.2	.....	.....	.80	1.08	.....	1.09	.....	.....	.....	2.3
Feb. 15	4.4	.....	.....	.....	1.24	.....	.....	.....	.....	.....	4.6
Feb. 16	.....	.....	.....	.80	.....	.....	.....	.....	.....	.....	.....
Feb. 18	2.2	.....	.....	1.15	1.29	.....	1.11	.85	.....	.....	2.2
Feb. 20	2.6	.....	.....	.94	1.18	.....	1.13	.....	.....	.....	2.4
Feb. 21	1.4	0.94	1.06	1.20	1.36	1.55	1.30	.....	.....	.....	1.4
Feb. 22	.....	.....	.....	.....	.....	.....	1.26	.....	.....	.....	.....
Feb. 24	3.0	.....	.....	.....	1.20	.....	.....	.....	.....	.....	2.6
Feb. 25	.....	.....	.....	.....	1.03	.....	.....	.....	.....	.....	.....
Feb. 27	1.8	.....	.....	.....	.....	.....	1.30	.....	.....	.....	1.6
Feb. 28	1.1	.....	.....	.....	.....	.....	1.09	.....	.....	.....	1.2
Means	.....	0.94	1.08	1.10	1.27	1.55	1.25	1.15	1.14	1.10	.....

TABLE 2.—*Average daily totals of solar radiation (direct diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Miami	New Orleans	Riverside	Blue Hill	Mount Washington	Friday Harbor	Ithaca
	Gram-calories per square centimeter													
1935	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 29	287	148	195	103	202	95	37	362	270	251	224	118	100	200
Feb. 5	244	140	344	80	158	208	30	376	208	237	247	229	207	182
Feb. 12	186	105	192	82	165	294	54	333	206	361	260	174	144	134
Feb. 19	315	228	297	167	185	367	100	411	317	400	305	122	208	193
	Departures from weekly normals													
Jan. 29	+82	−38	−28	−13	+53	−127	+6	+12	+47	−25				
Feb. 5	+33	−65	+82	−51	+2	−52	−11	+16	−2	−55				
Feb. 12	−39	−118	−81	−61	−7	−14	−6	−35	−12	+15				
Feb. 19	+53	−25	−1	−15	−9	+19	−8	+39	+74	+96				
	Accumulated departures on Feb. 25													
	+1666	−2177	−357	−763	+616	−602	−196	+630	+1617	−518				

TABLE 2-A.—*Late data.—Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning—	Mount Washington	Ithaca	Week beginning—	Mount Washington	Ithaca
1934	*Gr. cal.*	*Gr. cal.*	1934	*gr. cal.*	*gr. cal.*
Oct. 1		309	Dec. 3	121	79
Oct. 8		301	Dec. 10	138	82
Oct. 15		180	Dec. 17	88	85
Oct. 22		136	Dec. 24 [1]	85	115
Oct. 29	81	177	1935		
Nov. 5	122	78	Jan. 1	88	126
Nov. 12	148	111	Jan. 8	77	75
Nov. 19	122	89	Jan. 15	101	93
Nov. 26	74	64	Jan. 22	94	168

[1] 8-day mean.

TABLE 3.—*Total, I_m and screened, I_y, I_r, solar radiation intensity measurements, obtained during February 1935 and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated*

AMERICAN UNIVERSITY, WASHINGTON, D. C.

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	$\beta_{I_{m-r}}$	$\beta_{I_{y-r}}$	β_{mean}	$\frac{I_{w-o}}{1.94}$ Percentage of solar constant	$\frac{I_{w-r}-I_m}{1.94}$ Percentage of solar constant	w	Air-mass type
Feb. 1, 1935	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
2:45 a. m.	21 52	2.67	0.988	0.752	0.659	0.104	0.138	0.121	53.9	2.6	0.3	Pc
2:01 a. m.	27 08	2.19	.977	.697	.576	.100	.146	.123	53.6	3.5	.6	
Feb. 18												
3:45 a. m.	17 11	3.35	.920	.716	.595	.078	.082	.080	55.7	7.5	1.5	[1] N_{PC}
Feb. 21												
3:40 a. m.	18 47	3.08	1.148	.838	.712	.048	.088	.068	61.2	2.7	.3	Pc
3:31 a. m.	19 35	2.96	1.169	.839	.714	.042	.098	.070	61.8	2.4	.3	
Feb. 25												
4:13 a. m.	14 11	4.02	.916	.695	.581	.054	.068	.061	57.2	10.2	3.9	N_{PC}
Feb. 27												
4:12 a. m.	14 52	3.85	1.149	.783	.632	.028	.038	.033	64.8	6.2	.7	Pc
3:24 a. m.	23 00	2.55	1.165	.917	.760	.082	.070	.076	63.0	3.8	.8	
3:20 a. m.	23 39	2.49	1.170	.919	.762	.087	.071	.079	63.0	3.5	.9	
2:41 a. m.	29 38	2.02	1.343	1.022	.805	.046	.016	.031	78.8	9.8	6.6	
2:37 a. m.	30 11	1.98	1.360	1.024	.807	.044	.016	.030	79.8	9.4	5.8	
0:49 a. m.	41 14	1.52	1.490	1.078	.850	.014	.014	.014	86.8	10.7	13.2	
0:44 a. m.	41 31	1.51	1.510	1.080	.852	.012	.014	.013	86.9	10.1	10.1	

Atmospheric conditions during turbidity measurements

Feb. 1: Temperature, −8° C.; wind, S. 8; no polarization measurements because of snow cover.
Feb. 18: Temperature, 2° C.; wind, SW. 12; polarization, 56 percent; blueness of sky, 6.
Feb. 21: Temperature, −2° C.; wind, NW. 12; no polarization, snow cover.
Feb. 25: Temperature, 1° C.; wind, S. 10; no polarization, light snow.
Feb. 27: Temperature, −6° C.; wind, NW. 14; no polarization, snow.

[1] Air mass changed to NP_T about noon.

TABLE 3.—*Total, I_m, and screened, I_s, I_r, solar radiation intensity measurements, obtained during February 1935, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated*—Continued

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle	Solar altitude	Air mass	I_m	I_s	I_r	β_{1m-r}	β_{1s-r}	β_{m-ozo}	$\frac{I_{m-r}}{1.94}$	$\frac{I_{s-0_3}I_m}{1.94}$	w	Air-mass type
									Percentage of solar constant			
Feb. 1, 1935	° ′	m	*gr. cal.*	*gr. cal.*	*gr. cal.*						mm	
2:24 a. m.	21 55	2.66	1.288	0.943	0.781	0.038	0.047	0.042	70.2	5.7	4.6	Pc
1:59 a. m.	24 33	2.40	1.344	.968	.793	.031	.052	.042	71.5	4.0	4.8	
1:22 p. m.	27 38	2.15	1.403	1.001	.807	.024	.032	.028	77.8	7.6	6.2	
1:42 p. m.	26 05	2.27	1.406	1.003	.810	.019	.029	.024	78.6	8.1	6.0	
2:28 p. m.	21 29	2.71	1.375	.983	.800	.011	.039	.025	74.7	5.9	4.7	NPc
2:55 p. m.	18 12	3.18	1.335	.960	.785	.008	.025	.016	74.6	7.6	4.2	NPF, aloft
Feb. 6												
2:52 a. m.	19 49	2.93	1.213	.922	.770	.078	.059	.068	63.0	2.2	3.5	Pc
2:25 a. m.	23 06	2.54	1.272	.947	.795	.056	.071	.064	66.3	2.6	4.1	NPF, aloft
0:41 a. m.	31 17	1.92	1.292	.944	.778	.072	.096	.084	68.4	3.8	6.0	
Feb. 7												
2:52 a. m.	20 14	2.88	1.311	.978	.819	.038	.050	.044	68.0	2.3	3.6	Pc
2:29 a. m.	22 56	2.78	1.385	1.015	.834	.020	.029	.024	75.3	5.8	4.6	
1:05 a. m.	30 25	1.97	1.451	1.044	.848	.032	.036	.034	77.9	5.1	6.3	
0:45 a. m.	31 26	1.92	1.466	1.044	.843	.020	.034	.027	80.0	6.5	6.8	
0:06 a. m.	32 46	1.84	1.473	1.052	.867	.038	.057	.048	80.8	6.9	7.2	
0:13 p. m.	32 16	1.87	1.458	1.047	.852	.034	.043	.038	77.8	4.7	6.5	Pc, TF aloft
1:41 p. m.	27 49	2.14	1.419	1.026	.835	.030	.050	.040	75.0	3.9	5.4	
Feb. 11												
0:10 p. m.	33 36	1.80	1.390	.979	.805	.049	.061	.055	75.0	5.2	6.9	NPc, NPF aloft
Feb. 12												
3:03 a. m.	19 56	2.92	1.247	.938	.792	.049	.065	.057	64.4	1.7	3.3	
2:40 a. m.	22 58	2.55	1.325	.983	.817	.043	.051	.047	68.2	1.7	3.7	Pc, TA aloft
1:20 a. m.	31 00	1.94	1.454	1.046	.853	.034	.039	.036	78.7	5.8	6.6	
Feb. 15												
1:21 a. m.	31 54	1.89	1.311	.907	.737	.040	.076	.058	73.5	7.6	7.1	NPF, TG aloft
0:51 a. m.	33 38	1.80	1.311	.924	.740	.046	.058	.052	75.6	9.2	10.0	
0:14 a. m.	34 58	1.74	1.351	.961	.764	.044	.026	.035	79.5	3.5	6.5	
Feb. 18												
2:44 a. m.	24 12	2.43	1.267	.924	.763	.037	.051	.044	71.7	7.9	5.6	Pc, NPF aloft
2:11 a. m.	28 06	2.12	1.265	.919	.756	.058	.074	.066	69.7	6.0	6.0	
2:43 p. m.	24 20	2.42	1.018	.776	.632	.097	.086	.092	61.6	11.9	5.9	NPF, TF aloft
Feb. 20												
2:37 a. m.	25 43	2.08	1.160	.814	.682	.073	.129	.101	63.3	4.8	5.9	TF
1:34 a. m.	32 31	1.86	1.218	.864	.719	.079	.118	.098	66.5	4.1	6.3	
1:12 a. m.	36 39	1.67	1.281	.903	.750	.078	.135	.106	70.1	5.5	7.5	
Feb. 21												
2:55 a. m.	23 32	2.50	1.283	.932	.777	.043	.068	.056	68.2	3.5	4.6	Pc
2:31 a. m.	26 58	2.20	1.343	.969	.799	.046	.074	.060	71.0	3.4	5.1	
2:08 a. m.	29 29	2.02	1.358	.974	.799	.046	.054	.050	73.8	5.3	6.2	
1:45 a. m.	31 51	1.89	1.387	.976	.798	.044	.062	.053	74.4	4.5	6.4	
0:10 a. m.	37 01	1.66	1.428	.998	.814	.040	.065	.052	76.7	5.7	7.6	
Feb. 22												
0:25 a. m.	37 08	1.65	1.345	.950	.775	.054	.081	.068	74.1	6.3	7.8	Pc, NTF aloft
0:05 a. m.	37 26	1.64	1.350	.948	.762	.050	.062	.056	76.2	8.1	8.2	
Feb. 24												
2:08 a. m.	30 21	1.98	1.200	.858	.699	.066	.088	.077	70.0	9.4	7.0	Pc
Feb. 28												
1:20 a. m.	35 23	1.72	1.230	.865	.695	.061	.083	.072	73.7	11.5	8.1	Pc, NPF aloft

Atmospheric conditions during solar radiation measurements, Blue Hill Observatory of Harvard University

Date and time from apparent noon	Air temperature	Wind (Beaufort Scale)	Visibility (scale 0–10)	Sky blueness	Cloudiness and remarks
February 1935	°C.				
1; 2:21 a. m.	−14.1	W 2	8	6	2 Ci.
1; 1:27 p. m.	−6.1	WSW 3	9	7	1 Ci.
1; 2:38 p. m.	−4.4	SWx8 3	8–9	11	Few Ci, Cist, light haze.
1; 4:01 p. m.	−4.7	SW 4	8	6	1 Ci, few Cu.
6; 2:46 a.m.	−17.2	N 5	7–9	9	Few Frcu, heavy haze; inversion.
6; 1:24 p. m.	−8.9	NNW 2	6–7	9	Few Frcu, heavy smoke.
6; 2:58 p. m.	−7.8	NNW 3	6–7	10	No clouds, heavy smoke.
7; 2:48 a. m.	−9.9	NWxW 3	8–9	12	Few Cist; inversion.
7; 1:02 a. m.	−6.7	NNW 2	8–9	8	Few Cist; inversion.
7; 0:03 a. m.	−5.6	NNW 2	8–9	8	Few Cist; inversion.
7; 1:47 p. m.	−3.2	SW 3	8	12	No clouds, light haze.
7; 3:55 p. m.	−1.7	SW 3	8	10	Few Ci.
11; 0:13 a. m.	±0.0	WNW 5	8–9	7	5 Cu.
12; 2:59 a. m.	−15.6	NNW 3	8–9	10	1 Ci, Cicu.
13; 3:10 a. m.	−5.6	N 4	6	9	3 Stcu, heavy haze over sun.
13; 0:00 m.	−2.8	NE 3	7	7	1 Acu, 1 Cu. haze.
13; 1:41 p. m.	−2.2	NE 3	7	9	Fumulus, few Cu, heavy haze.
15; 1:12 a.m.	−2.8	WxS 3	8	10	1 Cist, few Cunb, moderate haze.
18; 2:41 a.m.	−6.7	WSW 4	7–8	11	1 Ci, Cist, 2 Acu.
18; 3:31 p. m.	+0.3	SSW 5	8	4	Few Acu, haze.
20; 2:56 a. m.	−2.8	SSW 5	7	9	Few Stcu, Cu, moderate water haze.
20; 1:31 a. m.	−1.1	WxS 5	7–8	9	1 Ci, Acu, moderate water haze.
21; 3:22 a.m.	−8.9	W 4	8–9	8	Few Ci, Cist.
21; 2:04 a. m.	−8.1	WNW 4	8–9	10	1 Ci, Cist.
21; 0:05 a. m.	−6.1	WNW 4	9	10	4 Cicu, 1 Cu, few Acu, no haze.
21; 1:01 p. m.	−4.2	SW 4	8–9	11	1 Ci, 4 Cu, Stcu.
24; 2:29 a. m.	−3.9	W 4	7	10	Few Ci, Cist, moderate haze.
27; 1:41 p. m.	−7.8	WNW 5	8	11	1 Cist, few Acu, few Cu, light haze.
27; 4:24 p. m.	−5.6	NW 5	9	11	4 Stcu 5° from sun, light haze.
28; 3:17 p. m.	−3.8	WSW 5	7	8	2 Frcu, Cu, heavy water haze.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy, Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1935	h m	°	°	°				
Feb. 1	10 59	+51.0	154.5	+30.5	93		93	U. S. Naval.
Feb. 2	11 18	+65.0	155.2	+30.0	93		93	Do.
Feb. 4	12 7	−78.0	345.4	+23.0	31		31	Do.
Feb. 5	— —	No spots						Harvard.
Feb. 6	13 26	−49.5	346.9	+22.5	77			U. S. Naval.
		+29.0	65.4	−16.5		370	447	
Feb. 7	11 4	−37.5	347.0	+22.5	62			Do.
		+42.5	67.0	−17.0		586	648	
Feb. 8	13 48	−23.0	346.8	+22.5	39			Do.
		+56.5	66.3	−17.5		556	595	
Feb. 9	11 10	−12.0	346.0	+22.0	12			Mt. Wilson.
		+66.0	64.0	−18.0		831	843	
Feb. 10	11 0	0.0	345.0	+22.0	8			Do.
		+74.0	59.0	−18.0		506	514	
Feb. 11	14 15	+16.5	346.6	+22.5	31		31	U. S. Naval.
Feb. 12	13 17	−79.0	238.4	+3.0	31			Do.
		+29.5	346.9	+22.5	23		54	
Feb. 13	13 58	−68.0	235.9	+3.0		123		Do.
		−23.5	280.4	+28.0		15	138	
Feb. 14	10 43	−54.5	238.0	+2.0		128	128	Harvard.
Feb. 15	10 45	−43.0	236.3	+1.5		51		Do.
		−50.0	229.3	0.0		19	70	
Feb. 16	10 26	−29.5	236.8	+2.0		15		U. S. Naval.
		+12.0	278.3	+28.5		62	77	
Feb. 17	12 3	+27.0	279.3	+29.0		31	31	Do.
Feb. 18	11 9	+41.0	280.6	+27.0	15		15	Do.
Feb. 19	11 4	No spots						Do.
Feb. 20	13 11	−62.5	149.6	+30.0	39			Do.
		+16.5	228.6	−26.5		62		
		+65.0	277.1	−14.0		62	163	
Feb. 21	11 18	−50.0	150.0	+30.5	46		46	Do.
Feb. 24	12 10	−0.5	159.5	−22.0		108	108	Do.
Feb. 25	11 12	−75.0	72.4	−18.5	123			Do.
		+14.0	161.4	−22.0		46	169	
Feb. 26	11 5	−61.0	73.3	−17.0	221			Mt. Wilson.
		+27.0	161.3	−23.0	8		229	
Feb. 27	11 5	−48.0	73.1	−18.5	185		185	U. S. Naval.
Feb. 28	11 1	−34.5	73.5	−18.5	154		154	Do.
Mean daily area for 25 days							194.	

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR FEBRUARY 1935

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

February 1935	Relative numbers	February 1935	Relative numbers	February 1935	Relative numbers
1		11	21	21	21
2		12	*Wcd* 26	22	7?
3		13	18	23	*Mc*17
4	*Mc*	14		24	*a* 17
5	*a*	15	*Mc* 22	25	*d*
6	29	16	20	26	18?
7	46	17	10	27	20
8	29	18	7	28	20
9	23	19	*Mc* 19		
10	28?	20	28		

Mean: 21 days=21.2.

a=Passage of an average-sized group through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in Charge]

By L. T. SAMUELS

Free-air temperatures during February averaged mostly above normal except over Pensacola, Norfolk, and Pearl Harbor (see table 1). The largest departures occurred in the lower levels over Pensacola. Relative humidity departures were mostly positive except over Pensacola and Seattle; the largest departures occurred over Pensacola. Temperature and relative humidity departures are included only for those stations where the length of record is sufficient to obtain a fairly satisfactory normal.

The monthly free-air temperatures averaged lowest over the northeastern part of the country and highest over the Gulf coast. The free-air relative humidities averaged highest over the extreme Northwest, the Ohio Valley, and New England. The region of lowest relative humidity was the Gulf coast.

The free-air resultant winds deviated most from the normal directions over the extreme Northwest, where marked southerly components occurred as compared to the normal westerly. Elsewhere the directions were close to normal (see table 2). Free-air resultant wind velocities were mostly above normal over the southeastern part of the country and generally below normal elsewhere. In most cases the departures from normal were of only moderate magnitude.

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during February 1935*

TEMPERATURE (°C.)

Stations	Altitude (meters) m. s. l.																Number of observations
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Billings, Mont.[1] (1,088 m)	−2.2						1.8		0.6		−2.2		−5.0		−11.7		−18.3		27
Cheyenne, Wyo.[1] (1,873 m)	−3.7								−1.9		−0.7		−3.7		−10.5		−17.3		28
Fargo, N. Dak.[1] (274 m)	−6.7		−5.5		−4.7		−5.0		−6.1		−8.0		−10.5		−16.0		−22.4		28
Kelly Field (San Antonio), Tex.[2] (206 m)	7.7		11.1		11.7		9.7		7.6		4.5		1.6		−4.8		−11.8		24
Lakehurst, N. J.[2] (39 m)	−4.0		−3.7		−4.6		−5.4		−7.4		−10.1		−12.7		−18.5				16
Maxwell Field (Montgomery), Ala.[2] (52 m)	6.0		7.8		6.6		5.1		2.9		0.7		−1.8		−6.7		−13.6		24
Mitchel Field (Hempstead, L. I.), N. Y.[2] (29 m)	−2.0		−1.1		−2.3		−2.9		−4.3		−6.2		−8.6		−14.0		−20.4		26
Murfreesboro, Tenn.[1] (174 m)	3.3		3.3		2.1		0.9		−0.5		−2.7		−4.9		−10.5		−16.3		27
Norfolk, Va.[3] (10 m)	1.2	−2.5	2.1	−1.2	1.3	−0.7	−0.2	−0.7	−1.8	−0.7	−3.8	−0.6	−5.6	−0.4	−10.2	−0.2	−15.9	−0.2	22
Oklahoma City, Okla.[1] (391 m)	2.8		3.9		4.6		3.9		2.5		0.0		−2.7		−8.9		−15.9		25
Omaha, Nebr.[1] (300 m)	−3.0	+1.4	−1.4	+2.0	−0.5	+1.1	−1.3	0.0	−1.6	+0.8	−3.6	+1.0	−6.2	+1.0	−11.7	+1.4	−18.0	+1.5	27
Pearl Harbor, Territory of Hawaii[2] (6 m)	19.6	−2.7	18.7	−1.0	14.8	−1.0	12.0	−1.3	11.1	−0.2	9.0	−0.6	6.2	−1.4	1.0	−1.4	−4.2	−1.4	27
Pensacola, Fla.[2] (24 m)	4.7	−5.6	5.9	−4.8	4.6	−4.5	4.2	−3.2	2.2	−3.2	1.0	−2.2	−0.7	−1.6	−5.4	−0.9	−11.8	−0.9	12
San Diego, Calif.[3] (10 m)	10.6	−1.9	12.7	+0.5	11.0	+0.3	8.4	0.0	6.0	0.0	3.5	0.0	0.7	−0.2	−5.5	+0.1	−12.6	+0.1	26
Scott Field (Belleville), Ill.[2] (135 m)	−0.3		1.5		1.5		0.9		−1.1		−3.3		−5.8		−11.4		−16.8		14
Seattle, Wash.[3] (25 m)	4.3	−2.6	6.3	+0.7	4.9	+2.1	1.5	+1.5	−1.1	+1.6	−3.7	+1.7	−6.4	+1.8	−12.3	+0.8			11
Selfridge Field (Mount Clemens), Mich.[2] (177 m)	−6.5		−6.2		−7.1		−7.3		−8.3		−10.1		−12.4		−17.2		−23.3		25
Spokane, Wash.[4] (596 m)	−0.6				0.5		0.1		−1.4		−3.5		−6.1		−12.3		−18.7		27
Sunnyvale, Calif.[3] (10 m)	7.6	−2.8	9.2	−0.7	8.2	0.0	6.4	+0.1	4.5	+0.2	2.5	+0.6	0.2	+0.9	−5.3	+1.7	−10.9	+1.7	22
Washington, D. C.[2] (13 m)	−2.3	−3.0	−1.3	−1.6	−2.2	−1.0	−3.0	−0.5	−4.1	−0.2	−5.9	0.0	−7.5	+0.4	−12.3	+1.0	−17.9	+1.0	22
Wright Field (Dayton), Ohio,[2] (244 m)	−2.6		−3.4		−4.4		−4.7		−5.8		−7.7		−9.5		−14.6		−20.7		22

RELATIVE HUMIDITY (PERCENT)

Billings, Mont.	63						51		45		42		43		41		43		
Cheyenne, Wyo.	58								56		49		47		46		44		
Fargo, N. Dak.	83		79		70		61		53		50		50		47		43		
Kelly Field (San Antonio), Tex.	84		74		59		52		46		45		44		42		40		
Lakehurst, N. J.	68		63		58		53		48		43		42		42				
Maxwell Field (Montgomery), Ala.	79		64		53		44		41		37		38		28		35		
Mitchel Field (Hempstead, L. I.), N. Y.	78		72		71		67		67		66		64		60		57		
Murfreesboro, Tenn.	79		73		70		66		59		56		54		50		49		
Norfolk, Va.	74	+3	67	+4	64	+6	61	+7	59	+9	57	+9	52	+7	45	+7	40	+6	
Oklahoma City, Okla.	74		70		61		53		45		42		43		41		41		
Omaha, Nebr.	87	+6	80	+4	69	+5	63	+6	53	+1	51	−1	55	+3	52	+3	50	+4	
Pearl Harbor, Territory of Hawaii	79	+8	74	+2	78	+2	71	+3	57	−1	50	+4	45	+10	34	+8	37	+8	
Pensacola, Fla.	75	−4	62	−6	60	−5	46	−14	37	−18	30	−21	26	−21	23	−22	21	−22	
San Diego, Calif.	84	+12	67	+3	57	+1	51	+2	49	+6	47	+8	44	+9	41	+8	40	+8	
Scott Field (Belleville), Ill.	76		63		54		46		41		37		37		37		33		
Seattle, Wash.	87	+13	70	+2	62	−4	61	−4	57	−6	50	−9	46	−10	43	−13			
Selfridge Field (Mount Clemens), Mich.	78		79		78		68		58		50		48		50		42		
Spokane, Wash.	86				76		65		60		55		51		50		49		
Sunnyvale, Calif.	86	+9	69	+2	64	+2	58	+4	50	+3	45	+3	45	+6	42	+6	41	+6	
Washington, D. C.	76	+4	68	+4	65	+4	59	+2	57	+3	56	+3	51	0	49	−1	44	−1	
Wright Field (Dayton), Ohio	79		80		77		70		59		55		54		46		42		

[1] Weather Bureau. [2] Army. [3] Navy. [4] National Guard.

Observations taken about 5 a. m., 75th meridian time, except along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—The departures are based on "normals" covering the following total number of observations: Norfolk 107, Omaha 109, Pearl Harbor 93, Pensacola 97, San Diego 123, Seattle 53, Sunnyvale 44, Washington 149.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 6 a. m. (E. S. T.) during February 1935*

[Wind from N=360°, E=90°, etc.]

Altitude (m) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (153 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (274 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Murfreesboro, Tenn. (180 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	340	1.4	309	2.5	254	3.8	275	1.8	287	4.9	300	2.1	288	1.1	287	1.9	269	1.3	347	1.6	40	2.1	223	0.2	336	0.9
500			306	4.3			290	6.6			310	4.3	255	4.1	307	5.1	296	3.5	284	2.1	77	2.3	15	0.4	261	2.7
1,000			304	6.6			294	8.1			314	6.2	271	8.4	302	6.6	318	6.2	282	3.8	156	1.5	150	2.9	267	5.8
1,500			292	7.1	271	8.8	298	9.3			295	9.0	266	10.7	287	7.8	321	7.8	292	5.4	213	1.5	165	4.1	275	8.9
2,000	276	1.7	303	9.4	292	8.2	287	11.1	290	7.0	297	10.3	277	8.4	287	7.5	316	10.3	300	5.8	221	3.8	202	4.8	283	11.1
2,500	282	2.7	301	9.7	294	8.6	284	12.6	303	10.0	299	13.4			319	8.4	312	12.2	319	6.3	229	4.0	207	4.6	287	10.1
3,000	289	2.5			294	8.9	285	15.0	305	10.0							317	14.4	334	8.2	235	4.3	210	4.0	293	12.3
4,000	337	3.1			303	9.4			298	9.6									328	6.2	265	5.9	223	1.8		
5,000	2	5.7			241	2.3			260	4.5									328	7.4						

Altitude (m) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii [1] (68 m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	289	1.7	74	0.9	342	1.5	19	0.7	50	3.8	23	2.8	285	1.5	163	1.7	78	1.2	24	0.9	161	1.1	93	0.7	297	1.1
500	297	6.6	25	2.9	264	2.0	312	1.7	54	6.6	336	3.2	279	5.3			308	0.3	325	1.9	183	3.5			288	6.3
1,000	292	7.0	53	1.1	299	5.5	302	7.4	62	5.8	296	6.6	286	9.9			41	1.8	327	5.0	192	3.9	116	2.1	278	8.2
1,500	271	9.8	26	0.3	320	6.0	308	8.7	81	4.4	285	6.9	291	11.0	170	2.8	34	2.5	331	5.5	210	3.9	195	2.0	286	10.1
2,000	271	9.8	352	1.4	309	7.0	312	9.2	73	3.6	285	6.6	298	11.8	183	2.8	39	2.9	316	8.3	209	3.6	229	3.0	288	13.0
2,500			323	3.3	323	8.7	301	10.1	81	2.6	264	8.3	311	13.4	256	2.3	21	2.8	319	7.3	207	3.6	253	4.4	287	9.9
3,000			313	3.4	324	9.8	317	9.5	70	4.2	284	10.8	313	15.4	276	4.2	332	3.0	317	7.8	247	2.1	257	4.3		
4,000			357	4.3											290	6.0	324	5.5					302	3.6		
5,000																	57	2.4					276	5.5		

[1] Navy stations.

RIVERS AND FLOODS

[River and Flood Division, MONTROSE W. HAYES, in charge]

By RICHMOND T. ZOCH

The accompanying table shows the places at which flood stages were reached during February. Except for the flood in the Tallahatchie River, which has not subsided and report on which cannot be made in this issue of the REVIEW, these overflows were of minor consequence and caused only slight damage.

The flood in the Allegheny River was the result of an ice gorge. This gorge caused considerable apprehension among the people near the river, but eventually moved out without any damage to property.

Table of flood stages in February 1935

[All dates in February unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
	Feet			*Feet*	
Roanoke: Williamston, N. C.	10	20	23	10.3	21-23
Neuse: Smithfield, N. C.	12	28	28	13.8	28
Cape Fear: Lock No. 2, Elizabethtown, N. C.	20	16	18	21.6	16
Peedee: Mars Bluff Bridge, S. C.	17	19	21	17.4	20
Saluda:					
Pelzer, S. C.	6	15	17	6.1	16
Chappells, S. C.	13	15	16	14.83	16
Santee:					
Rimini, S. C.	12	17	23	13.4	19
Ferguson, S. C.	12	18	24	13.1	21, 23
Savannah: Ellenton, S. C.	14	16	21	18.0	18
EAST GULF OF MEXICO DRAINAGE					
	Feet			*Feet*	
Cahaba: Centerville, Ala.	23	15	15	26.0	15
Tombigbee: Lock No. 3, Ala.	33	16	21	37.0	19
Pearl: Pearl River, La.	12	17	22	13.0	19
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Rock: Moline Bridge, Ill.	10	19	20	10.9	20
Skunk: Augusta, Iowa	12	16	19	13.66	16
Illinois:					
Peru, Ill.	17	16	16	17.0	16
Havana, Ill.	14	26	(1)	(1)	(1)
Beardstown, Ill.	14	27	(1)	(1)	(1)
Ohio Basin					
Allegheny: Parkers Landing, Pa.	18	27	28	20.5	27
Red Basin					
Sulphur:					
Ringo Crossing, Tex.	20	14	14	20.0	14
Naples, Tex.	22	19	19	22.4	19
Lower Mississippi Basin					
Big Lake Outlet: Manila, Ark.	10	Jan. 3	(1)	(1)	(1)
St. Francis: St. Francis, Ark.	18	Jan. 21	2	21.7	Jan. 26
Tallahatchie: Swan Lake, Miss.	26	Jan. 10	(1)	(1)	(1)
Atchafalaya Basin					
Atchafalaya: Atchafalaya, La.	22	1	17	22.8	8-11

[1] Continued into March.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, W. F. McDONALD in Charge]

NORTH ATLANTIC OCEAN, FEBRUARY 1935

By H. C. HUNTER

Atmospheric pressure.—Pressure averaged considerably above normal over the south-central and southeastern portions of the North Atlantic, and slightly above normal over the Gulf of Mexico. The western portion of the ocean had pressure slightly below normal. The Icelandic LOW was unusually strong, especially from the 15th onward, and as a result the monthly average pressure over the northern portion of the ocean east of the fiftieth meridian was much below normal.

Between the 16th and 21st, the pressure gradient from Horta to Reykjavik was as a rule more than double the seasonal average. From the 22d onward, while Reykjavik pressure was not so low as before, the pressure at Lerwick, in the Shetland Islands, was generally very low.

The highest barometer reading reported was 30.74 inches, by the American steamship *Yaka*, on the forenoon of the 2d, near latitude 44° N., longitude 24° W. Readings almost as high were noted close to the North and Middle Atlantic coasts of the United States on the 1st and 7th, and again in the northern Gulf of Mexico on the last day of the month.

The lowest reading so far reported from a vessel was 28.33 inches, on the American steamship *President Harding* at 10 a. m., the 24th, near 51° N., 20° W. During the first 2 days of the month there was very low pressure between Iceland and Norway, one shore station of the latter country reporting a reading of 27.94 inches on the 2d.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, February 1935*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.28		29.68	10	28.68	6
Reykjavik, Iceland	29.27	−0.27	29.83	5	28.66	1
Lerwick, Shetland Islands	29.33	−.39	30.29	8	28.37	21
Valencia, Ireland	29.72	−.18	30.46	7	28.81	25
Lisbon, Portugal	30.20	+.10	30.47	2	29.82	25
Madeira	30.25	+.18	30.40	28	29.99	7
Horta, Azores	30.27	+.12	30.54	1	30.01	10
Belle Isle, Newfoundland	29.68	−.07	30.22	24	29.34	5, 25
Halifax, Nova Scotia	29.92	+.01	30.54	23	29.46	3, 4
Nantucket	29.99	−.05	30.78	1	29.42	3
Hatteras	30.07	−.04	30.56	1	29.50	3
Bermuda	30.12	.00	30.40	22	29.76	4
Turks Island	30.06	−.02	30.16	21	29.93	3
Key West	30.10	+.03	30.43	28	29.87	11
New Orleans	30.14	+.05	30.71	28	29.78	15

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observations, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—While the first half of February was relatively quiet over the North Atlantic Ocean, the second half was marked by intense gales. In all, there have been received 12 reports of force 12, and 17 of force 11. All except 3 of these occurred during the last 11 days of the month.

An intense LOW was central near Norway early in the month; and one encounter with a gale of force 11 on the 1st was noted by the Swedish steamship *Braheholm* in the waters near Scotland. Thereafter there were very few reports of gales until the 6th, and not many afterward until the 15th.

During the 15th and 16th a well-developed storm traveled northeastward past the Gulf of St. Lawrence, and the first February report of hurricane intensity (12) relates to this storm; the British motor ship *Laganbank* encountered it when about 400 miles east-southeast of Nantucket. This storm had merged with the Icelandic LOW by the 18th; and a later storm, which was near New Jersey on the 17th, had by the 19th become the southwestern portion of the more widespread LOW, and showed great intensity, the center on the 19th being near 55° N., 35° W., as appears on chart IX. The German steamship *New York* noted hurricane force that day, when located southeast of the position just mentioned.

During the several days following, there was widespread storminess over the northern routes; and violent winds were almost constantly met in the region from midocean to the Bay of Biscay and the English Channel. The reports of winds reaching forces 11 and 12 were numerous until late on the 26th, when the pressure increased somewhat and there was a slow eastward displacement of the depression. After the 26th, therefore, the winds became less intense over the northeastern North Atlantic. The conditions of the 24th are presented in chart X, as typical of the most stormy period.

Although conditions were abnormally severe along the eastern portion of the steamship routes, there was less storminess than February normally brings in the Grand Banks region and thence westward and southwestward to the coast of North America.

The British steamship *Blairgowrie* reported, when near latitude 48° N., longitude 27° W., on the 26th, that her steering gear was disabled and she called for assistance. Several vessels responded but found no trace of the ship.

On the British steamship *Montclare*, bound from Glasgow for Halifax, a large derrick snapped during this storm period; two men were killed and ten injured. There appear to have been no other casualties at sea involving loss of life, but several vessels suffered such damage as to result in their limping into port or having to be towed in.

The Dutch steamship *Beemsterdijk*, bound westward out of the English Channel during the night of the 15–16, had a typical experience, meeting a series of intense westerly gales in quick succession, and emerging into better sailing only on the 27th, after reaching the fortieth meridian. The after wheelhouse was wrecked, cabins were damaged, and the fuel supply was so depleted by the long struggle that the ship had to put into Halifax for refueling instead of making directly for Boston, as scheduled.

Similar instances of delay, or damage to superstructures and gear, on vessels that encountered the North Atlantic storms of the latter part of February were numerous.

The trade winds of the central Caribbean are reported to have been of more than usual strength about the 26th. Over the western Caribbean and that part of the Gulf of Mexico near the Yucatan Channel there were notable northers about the 18th and the 27th.

Fog.—Fog was practically absent over the area from the Bay of Biscay and the English Channel westward to the thirtieth meridian. Near the Grand Banks and thence westward to the vicinity of Nova Scotia fog was

a little more prevalent than average, and in this region the period 3d to 5th was notably foggy. In the 5° square, 40° to 45° N., 60° to 65° W., fog was reported on 8 days.

From Nova Scotia to Chesapeake Bay, about the normal amount of 5 days' fog was noted. The Chesapeake Bay region, however, had 8 days with fog, an unusually large amount for February in this locality.

The southern Atlantic and west Gulf coast regions had very little fog, but the east Gulf coast experienced more than normal, mostly on scattered dates between the 7th and 15th.

OCEAN GALES AND STORMS, FEBRUARY 1935

Vessel	Voyage		Position at time of lowest barometer		Gale began February—	Time of lowest barometer February—	Gale ended February—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Braheholm, Swed. S. S.	Newcastle	Norfolk	57 50 N.	14 40 W.	[1] 30	Noon, 1	2	29.36	W	W, 9	W	W, 11	
City of Bagdad, Br. S. S.	North Shields	St. John N.B.	51 30 N.	44 00 W.	2	6p, 2	3	29.73	WSW	WSW, 9	WSW	WSW, 9	
Boston City, Br. S. S.	Fowey	Philadelphia	47 39 N.	39 05 W.	5	6a, 6	6	29.41	SSE	SSE, 10	W	S, 10	SSE-SW-W.
Makala, Belg. S. S.	Matadi	Antwerp	46 42 N.	6 43 W.	6	4p, 8	8	[2] 29.99	N	NNE, 10	NE	NNE, 10	NNE-NE.
Stakesby, Br. S. S.	Madeira	Hull	37 45 N.	12 55 W.	8	8a, 9	9	29.93	N	N, 8	NNE	N, 9	N-NNE.
Independence Hall, Am. S. S.	New York	Havre	42 00 N.	55 16 W.	9	Mdt, 9	9	29.71	SSE	SSW, 4	SSW	SE, 9	SSE-SSW-WSW
Laganbank, Br. M. S.	Algiers	Boston	36 40 N.	55 32 W.	13	1a, 14	14	29.86	WNW	NW, 10	N	NW, 11	WNW-NW-NNW.
Gateway City, Am. S. S.	Mobile	Bremen	48 01 N.	29 40 W.	14	4p, 14	16	29.39	SSW	SSW, 9	NW	SW, 10	Steady.
Steel Mariner, Am. S. S.	Gibraltar	New York	37 35 N.	70 35 W.	15	5a, 15	15	29.70	S	SSW, 10	SW	SSW, 10	S-SSW-WNW.
Black Gull, Am. S. S.	New York	Rotterdam	41 02 N.	63 06 W.	15	2p, 15	15	29.44	SSW	SW, 8	WSW	SSW, 9	SSW-SW-W.
Laganbank, Br. M. S.	Algiers	Boston	39 32 N.	61 48 W.	15	4p, 15	15	29.67	SW	SW, 11	WSW	SW, 12	SW-WSW.
Leerdam, Du. S. S.	Rotterdam	New York	45 40 N.	44 48 W.	16	4p, 16	16	29.58	SSW	S, 9	S	SSW, 9	SSW-S.
Exochorda, Am. S. S.	Gibraltar	Boston	[3] 38 46 N.	47 50 W.	17	2p, 17	17	29.77	SSW	WNW, 7	WNW	SW, 10	SW-WNW.
Leerdam, Du. S. S.	Rotterdam	New York	43 36 N.	54 10 W.	18	5a, 18	19	29.26	SSE	S, 10	W	S, 11	SSE-S-WSW.
Lord Kelvin, Br. S. S.	Cable grounds out from Halifax.		43 27 N.	55 00 W.	18	6a, 18	18	29.30	SE	SW, 6	W	S, 10	S-SW.
Caledonia, Br. S. S.	Belfast	Halifax	54 00 N.	20 20 W.	18	2p, 18	18	28.96	N	N, 9	NNW	N, 9	SW-N.
Sinaloa, Hond. S. S.	Bluefields, Nicaragua.	New Orleans	15 40 N.	83 30 W.	18	do	19	30.04	NNW	NNW, 6	NNW	NNW, 7	None.
Frode, Dan. S. S.	Immingham	Halifax	50 40 N.	16 53 W.	18	4p, 18	18	29.31	SW	SW, 10	NW	SW, 10	SW-NW.
Duquesne, Am. S. S.	Houston	Havre	43 42 N.	41 21 W.	18	4a, 19	19	29.56	SW	W, 7	NNW	SW, 9	None.
New York, Ger. S. S.	Cherbourg	New York	48 30 N.	30 00 W.	18	8a, 19	20	28.87	SW	SW, 12	WNW	SW, 12	SW-WNW.
Frode, Dan. S. S.	Immingham	Halifax	50 40 N.	20 21 W.	19	2p, 19	20	28.84	SSW	SW, 10	NW	SW, 10	SSW-W-NW.
Caledonia, Br. S. S.	Belfast	do	51 53 N.	28 35 W.	19	3p, 19	19	28.41	SSE	W, 10	NW	W, 11	S-W.
American Shipper, Am. S. S.	do	New York	52 52 N.	26 58 W.	19	4p, 19	20	28.44	SSE	SW, 9	NW	SW, 11	SW-W.
Caledonia, Br. S. S.	do	Halifax	49 25 N.	37 05 W.	21	2a, 21	22	28.83	SW	WSW, 11	W	WSW, 11	SSE-WSW-W.
Beemsterdijk, Du. S. S.	Rotterdam	Boston	48 43 N.	29 14 W.	21	6a, 21	21	28.98	WSW	WNW, 11	NW	WNW, 11	WSW-WNW-NW.
Black Gull, Am. S. S.	New York	Rotterdam	49 13 N.	19 04 W.	21	4p, 21	21	28.71	SSW	W, 6	W	S, 10	W-NW.
Pres. Harrison, Am. S. S.	Gibraltar	New York	42 54 N.	39 30 W.	21	5p, 21	22	29.56	SSW	SW, 10	W	SW, 10	SSW-SW-WNW.
Lobos, Br. M. S.	Liverpool	Colon	45 00 N.	14 00 W.	21	8p, 21	22	29.32	SW	WSW, 10	NW	WNW, 11	SW-WNW.
Duquesne, Am. S. S.	Houston	Havre	45 54 N.	26 06 W.	21	4a, 22	22	29.32	W	WSW, 7	W	WNW, 10	SW-NW.
Camito, Br. S. S.	Avonmouth	Jamaica	47 28 N.	12 05 W.	22	3p, 22	23	28.62	SSW	WSW, 10	NW	W, 10	{SSW-WSW-NW.
City of Joliet, Am. S. S.	Rotterdam	Houston	46 10 N.	11 30 W.	22	4p, 22	22	28.96	SW	WSW, 12	WNW	WSW, 12	SW-WSW-W.
Delfshaven, Du. S. S.	Antwerp	Baltimore	44 22 N.	12 36 W.	22	do	23	29.59	WSW	WNW, 8	WNW	WNW, 11	WSW-WNW.
Samala, Br. S. S.	Southampton	Puerto Cortez	[3] 43 48 N.	20 27 W.	22	1a, 23	24	29.30	W	W, 9	W	W, 12	
Lobos, Br. M. S.	Liverpool	Colon	42 50 N.	16 30 W.	23	6a, 23	25	29.44	SW	W, 9	NW	WNW, 12	SW-WNW.
General Gassouin, Fr. S. S.	New York	Antwerp	45 51 N.	36 55 W.	23	2p, 23	24	29.46	W	W, 12	NW	W, 12	None.
Beemsterdijk, Du. S. S.	Rotterdam	Boston	47 42 N.	34 39 W.	23	4p, 23	24	29.28	W	WNW, 9	WNW	WNW, 11	W-WNW.
Eglantine, Am. S. S.	New Orleans	Avonmouth	48 10 N.	32 47 W.	22	10p, 23	25	29.12	W	NW, 9	NW	NW, 11	W-NW.
Scanyork, Am. S. S.	Copenhagen	New York	57 42 N.	21 48 W.	24	11p, 23	25	28.95	NNW	W 4	NW	NW, 10	ESE-S-W.
Pres. Harding, Am. S. S.	Cobh	do	50 53 N.	19 55 W.	24	10a, 24	25	28.33	N	NNW, 7	WNW	NNW, 10	SSW-NNW-N.
City of Joliet, Am. S. S.	Rotterdam	Houston	46 20 N.	15 00 W.	23	3p, 24	27	29.08	SW	WSW, 12	WNW	WSW, 12	W-WSW-WNW.
Belgian Gulf, Belg. M. S.	Manchester	Baytown, Tex.	47 46 N.	15 47 W.	23	do	25	28.66	W	WSW, 10	NW	WNW, 11	WSW-WNW.
Argosy, Am. S. S.	Copenhagen	Baltimore	45 30 N.	50 18 W.	24	9p, 24	25	29.31	SE	S, 7	W	WSW, 10	SE-WSW.
Bockenheim, Ger. S. S.	Tampa	Rotterdam	42 16 N.	44 41 W.	24	1a, 25	26	29.56	SW	WSW, 10	WNW	WNW, 11	SW-W.
American Merchant, Am. S. S.	London	Boston	44 18 N.	46 24 W.	25	do	25	29.43	WSW	W, 11	W	W, 11	SE-W.
Elsa, Nor. M. S.	Ghent	Philadelphia	48 29 N.	38 02 W.	25	10a, 25	26	[2] 29.08	SW	SW, 10	WNW	W, 11	SW-W.
Strabon, Fr. S. S.	Tenerife	Dunkirk	46 30 N.	7 20 W.	23	Noon, 25	26	[2] 28.94	NNW	WSW, 12	NW	WSW, 12	WSW-NW.
Frode, Dan. S. S.	Immingham	Halifax	49 06 N.	32 00 W.	25	10p, 25	26	28.88	SSE	WSW, 12	W	W, 12	SSE-SW-W.
Scanyork, Am. S. S.	Copenhagen	New York	53 55 N.	36 35 W.	26	Mdt. 25	26	28.71	WNW	WSW, 4	WNW	WNW, 12	SE-SW-WSW.
Adria, Ger. M. S.	Port Arthur	Bordeaux	44 13 N.	34 00 W.	24	4a, 26	27	[2] 29.56	NW	W, 11	WNW	W, 11	W-WNW.
Pres. Harding, Am. S. S.	Cobh	New York	[3] 49 58 N.	33 08 W.	25	8a, 26	27	28.53	S	W, 12	WNW	W, 12	None.
General Gassouin, Fr. S. S.	New York	Antwerp	48 10 N.	22 14 W.	25	8p, 26	27	28.95	SW	W, 12	WNW	W, 12	WSW-WNW.
Frederik VIII, Dan. S. S.	Oslo	New York	57 00 N.	22 30 W.	27	do	27	28.50	WNW	WNW, 4	WNW	WNW, 10	SE-WNW-N.
Eglantine, Am. S. S.	New Orleans	Avonmouth	48 25 N.	18 30 W.	26	10p, 26	27	29.01	WSW	W, 10	W	W, 10	WSW-W.
Chickasaw City, Am. S. S.	Cristobal	New Orleans	19 20 N.	83 50 W.	27	4p, 27	28	30.07	NNW	NNW, 4	NNE	NNW, 7	SE-NNW.
Jean Jadot, Belg. S. S.	New York	Antwerp	48 51 N.	30 44 W.	27	10p, 28	[4] 1	29.33	WSW	WSW, 10	WNW	WSW, 10	WSW-WNW.

[1] January. [2] Barometer uncorrected. [3] Position approximate. [4] March.

OCEAN GALES AND STORMS, FEBRUARY 1935—Continued

Vessel	Voyage		Position at time of lowest barometer		Gale began February—	Time of lowest barometer February—	Gale ended February—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH PACIFIC OCEAN			° ′	° ′				*Inches*					
California, Am. S. S.	Los Angeles	Yokohama	37 10 N.	161 12 E.	[1] 31	6a, 1	2	29.37	SE	SW., 8	NNW.	W, 10	WSW-SW-W.
General Sherman, Am. S. S.	Yokohama	San Francisco	45 52 N.	167 55 E.	[1] 31	3p, 1	2	28.95	SSE	ENE., 10	NNE.	ENE 11.	E-ENE.
Kentuckian, Am. S. S.	Balboa	Los Angeles	[3] 13 15 N.	92 53 W.	1	4a, 1	1	30.00	N	W, 2	NE	N, 8	W-N.
Kentucky, Am. S. S.	Darien	do	41 35 N.	138 10 W.	1	Noon, 1	1	29.54	SE	SE, 10	S	SE, 10	SE-S.
San Francisco, Fr. S. S.	Los Angeles	Balboa	15 26 N.	96 27 W.	2	3p, 2	3	29.96	ENE	ENE, 7	NNW.	NE, 8	ENE-NE.
Montgomery City, Am. S. S.	Honolulu	Shanghai	31 35 N.	144 35 E.	3	3p, 3	3	29.44	S	SW, 9	W	SW, 9	SSW-WSW
California, Am. S. S.	Los Angeles	Yokohama	36 50 N.	154 15 E.	3	2a, 4	4	28.96	SSE	SE, 9	WNW.	WNW, 9	SSE-SE-W.
Tulsagas, Am. S. S.	Balboa	San Francisco	14 18 N.	95 18 W.	3	4a, 4	4	29.98	NE	NNE, 8	NE	NNE, 8	NNE-NE.
President Monroe, Am. S. S.	Honolulu	Kobe	31 08 N.	157 08 E.	4	7a, 4	4	29.60	S	S, 9	WNW.	W, 11	SSE-S-WSW.
President Hoover, Am. S. S.	Yokohama	Honolulu	33 42 N.	162 56 E.	4	Noon, 4	4	29.36	SSE	S, 9	S	S, 9	SSE-S-W.
San Diego Maru, Jap. M. S.	Kobe	Los Angeles	37 48 N.	178 12 E.	4	Mdt., 5	5	[2] 29.04	SE	WSW, 4	S	S, 10	S-WSW.
Jeff Davis, Am. M. S.	Kelung	do	35 05 N.	174 30 E.	4	4a, 5	5	29.47	S	S, 10	WNW.	S, 10	S-Calm-WNW.
Stanley Dollar, Am. S. S.	Legaspi, P. I.	Portland, Oreg.	[3] 39 13 N.	168 07 E.	3	6p, 5	6	28.93	SE	W, 11	W	W, 12	None.
Silverguava, Br. M. S.	Dahikan, P. I.	do	41 11 N.	164 00 E.	4	5a, 5	6	28.64	SSE	SSW, 8	W	SW, 10	SSW-WSW.
Hokuroku Maru, Jap. M. S.	Yokohama	Los Angeles	46 36 N.	165 54 W.	5	4p, 6	6	28.90	ESE	WSW, 5	ENE.	ENE, 8	ENE-WSW-SW
President Monroe, Am. S. S.	Honolulu	Kobe	32 48 N.	146 00 E.	6	1p, 6	6	29.63	W	W, 9	W	W, 10	None.
Skramstad, Nor. M. S.	Los Angeles	Yokohama	32 15 N.	151 39 E.	6	4p, 6	7	29.60	SW	WNW, 9	NW	WNW, 9	Steady.
Jeff Davis, Am. M. S.	Kelung	Los Angeles	35 10 N.	169 30 W.	6	8p, 6	7	29.51	WSW	SW, 8	SW	SW, 10	Do.
Manoeran, Du. M. S.	Manila	do	33 12 N.	175 12 W.	6	Mdt., 6	7	29.44	WSW	SW, 8	SW	SW, 10	None.
Koyo Maru, Jap. S. S.	Yokohama	Port San Luis	37 43 N.	153 48 E.	7	Noon, 8	7	29.51	NNW.	NW, 6	NW	NW, 8	Steady.
Tyndareus, Br. S. S.	Vancouver	Yokohama	52 06 N.	165 54 W.	7	1a, 9	8	28.72	S	SSW, 6	NNE.	S, 8	SSW-N.
Manoeran, Du. M. S.	Manila	Los Angeles	34 54 N.	162 48 W.	8	1a, 10	9	29.52	SW	SW, 9	SW	SW, 9	None.
Pres. Jackson, Am. S. S.	Victoria	Yokohama	44 50 N.	155 30 E.	11	7p, 11	11	29.11	SSE	WNW, 4	SSW	S, 10	SSW-WNW-W
Tatsuno Maru, Jap. S. S.	Otaru	Los Angeles	44 03 N.	147 55 W.	11	Noon, 11	12	29.50	SW	SW, 8	WNW.	WSW, 10	SW-W.
Silverguava, Br. M. S.	Dahikan	Portland, Oreg.	[3] 46 40 N.	141 09 W.	11	9p, 11	12	29.13	W	W, 9	NW	W, 10	SW-W-WNW.
President Grant, Am. S. S.	Yokohama	Seattle	46 30 N.	157 03 E.	11	3p, 11	12	29.22	SSW	WSW, 8	W	SSW, 9	S-W.
Hikawa Maru, Jap. M. S.	do	Vancouver	47 54 N.	172 54 E.	12	11a, 12	12	29.29	S	S, 9	S	S, 9	
Tyndareus, Br. S. S.	Vancouver	Yokohama	47 44 N.	168 33 E.	12	Noon, 12	13	29.19	S	SW, 9	W	SW, 9	SW-WSW.
Tantalus, Br. M. S.	Yokohama	Victoria	49 12 N.	177 10 W.	12	1a, 12	12	29.47	S	SW, 1	S	S, 9	S-W.
Stanley Dollar, Am. S. S.	Legaspi	Portland, Oreg.	[3] 45 50 N.	130 27 W.	14	5p, 15	16	29.73	SSE	SE, 9	S	SE, 10	None.
Atlantic, Am. S. S.	Los Angeles	Balboa	16 00 N.	94 24 W.	17	4p, 17	17	[2] 29.90	NNE	NW, 7	NW	NNW, 9	N-NW.
Neches, U. S. N. Aux.	do	Manila	30 12 N.	136 18 W.	17	3p, 17	17	29.94	S	SSE, 9	SW	SSE, 9	SSE-WSW.
Steel Trader, Am. S. S.	Balboa	San Diego	12 54 N.	92 30 W.	17	8a, 17	18	29.96	NW	NW, 2	NE	NE, 10	
San Clemente, Am. S. S.	Los Angeles	Balboa	[3] 14 54 N.	93 54 W.	20	9p, 20	20	29.96	NNE	N, 6	N	N, 9	NE-N.
North Devon, Br. S. S.	Mazatlan	do	14 52 N.	93 10 W.	19	3a, 21	22	29.92	E	NNE, 9	N	NNE, 9	NE-N.
Golden Peak, Am. S. S.	San Francisco	Yokohama	34 30 N.	156 40 E.	21	6a, 21	21	29.65	W	W, 8	NW	NW, 9	S-W-NW.
Teiyo Maru, Jap. M. S.	Tokuyama	Los Angeles	42 12 N.	173 24 W.	22	1a, 23	23	28.97	WSW.	WSW, 7	W	W, 9	None.
Golden Peak, Am. S. S.	San Francisco	Yokohama	34 30 N.	151 20 E.	23	1p, 23	23	29.40	S	W, 11	WNW.	W, 11	S-W-NW.
Hiye Maru, Jap. M. S.	Yokohama	Vancouver	40 34 N.	151 25 E.	23	2p, 23	24	28.87	NNE.	N, 8	W	NW, 9	NNE-NW.
Empress of Asia, Br. S. S.	do	do	43 09 N.	157 33 E.	23	10p, 23	24	28.56	S	WNW, 9	WSW.	WNW, 9	S-WNW.
Amagisan Maru, Jap. M. S.	do	Los Angeles	41 53 N.	160 22 E.	23	9p, 23	24	29.23	SSE	S, 9	W	SSE, 9	SSE-S-WSW.
Olympia, Am. S. S.	do	Vancouver	49 30 N.	176 00 W.	23	4p, 24	24	29.90	S	SE, 9	S	SE, 9	SE-S.
General Lee, Am. S. S.	do	San Francisco	[3] 44 42 N.	177 14 E.	24	1a, 26	25	29.75	SE	S, 8	S	SSE, 9	
Mojave, Am. S. S.	Tacoma	Los Angeles	41 52 N.	124 38 W.	26	5a, 26	26	29.89	SSE	SSE, 8	SSW	SSE, 11	None.
Steel Inventor, Am. S. S.	Los Angeles	Balboa	13 54 N.	96 28 W.	27	4p, 27	[4] 1	29.86	NE	NE, 9	N	NE, 9	Do.
Pennsylvanian, Am. S. S.	do	do	14 58 N.	96 28 W.	27	4a, 28	[4] 1	29.93	E	NE, 8	N	N, 10	ENE-NNE.

[1] January. [2] Barometer uncorrected. [3] Position approximate. [4] March.

NORTH PACIFIC OCEAN, FEBRUARY 1935

By WILLIS E. HURD

Atmospheric pressure.—The principal features of the average pressure over the North Pacific Ocean during February 1935 were a belt of low pressure—the Aleutian cyclone—extending across much of the northern part of the ocean, and the usual belt of high pressure lying between the United States coast and middle latitudes of the Far East.

Throughout the upper-latitude cyclonic belt, as well as in the extreme southwestern tropics, pressures were below the normal; but along the American coast from Juneau to Mazatlan, and from the Hawaiian Islands westward to the Nansei group in the anticyclonic belt, pressures ranged from 0.01 to 0.11 inch above the normal, as shown by table 1.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, February 1935, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	29.92	−0.20	30.64	25	29.50	16
Dutch Harbor	29.52	−.08	30.28	24	28.84	8
St. Paul	29.59	−.06	30.34	24	28.76	20
Kodiak	29.51	−.11	30.28	26	28.76	14
Juneau	29.93	+.01	30.51	18	29.07	10
Tatoosh Island	30.10	+.10	30.54	17	29.20	12
San Francisco	30.15	+.05	30.49	16	29.81	6
Mazatlan	29.97	+.04	30.08	20	29.80	12
Honolulu	30.09	+.04	30.25	18	29.88	27
Midway Island	30.12	+.13	30.46	12	29.68	8
Guam	29.87	−.04	30.00	12	29.78	1, 27
Manila	29.87	−.02	29.98	1	29.76	24
Hong Kong	30.03	----------	30.23	12	29.87	25
Naha	30.10	+.05	30.28	13	29.88	25
Chichishima	30.09	+.11	30.34	9	29.90	2, 27
Nemuro	29.93	----------	30.36	8	29.54	6

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Cyclones and gales.—February was a stormy month on the North Pacific, though less so than the preceding month. As an evidence of this fact it may be stated that while in January there were at least 11 days on which gales of the highest forces (11–12) occurred, in February only 5 such days have thus far been reported. As in January, the greater number of gale winds experienced by shipping occurred to the westward of the one-hundred-and-eightieth meridian.

The month opened with scattered gales in east and west longitudes. Winds of forces 8–10 occurred between 40°–45° N., 130°–140° W., and of force 11, near 46° N., 168° E., the latter accompanied by a pressure of 28.95 inches.

On the 4th to 6th, gales were fairly general over the western half of the ocean north of the thirtieth parallel. This also was the period of roughest weather for the month, since forces of 11 to 12 were encountered in several localities between 30°–40° N., 150°–170° E., on the 4th and 5th, and forces of 9 and 10 were met over an immense region extending eastward from near the Japanese coast to 170° W. from late on the 3d until late on the 6th. The American steamer *Stanley Dollar* was in the gale field for 70 or more hours between 36° N., 159° E. and 40° N., 175° E., and experienced the heaviest weather of the 4th and 5th. The lowest barometer read on board a ship during this stormey period was 28.64, reported by the British motorship *Silverguava* on the 5th, near 41° N., 164° E., highest wind, force 10, southwest.

From the 6th to 9th a deep midocean storm, minimum pressure 28.70, prevailed between approximately 40° N. and the central Aleutians. Despite its depth, however, it was productive of no gales exceeding 8 in force except far to the south of its center where, between the western Hawaiian Islands and the thirty-fifth parallel, gales of force 9 to 10 were reported on the 6th and 9th.

On February 10 a depression appeared east of northern Japan. It moved northeastward until the 13th, when it was central north of St. Paul Island, Bering Sea. During its passage following the 10th, it caused gales along the northern routes, from the Kuril Islands on the 11th, eastward to about 175° E. on the 13th.

From the 11th to 18th scattered gales occurred over the region between 28°–50° N., 130°–150° W. Those of the 11th, which were experienced in the northwestern part of the area, attained a force of 10.

On the 13th and 17th distinct and separate depressions formed about midway along the California-Hawaii route. The earlier produced no gales except in higher latitudes, where forces of 9 to 10 occurred near 45° N., between 130° and 140° W., on the 14th and 15th. The second depression caused fresh gales near the locality of origin, approximately 30° N., 135° to 145° W.

The 23d and 24th were stormy days at localities along the western half of the northern and central routes. The maximum velocity was force 11, reported by the American steamer *Golden Peak*, near 35° N., 151° E., on the 23d. The lowest pressure of the month, 28.56 inches, was read on board the British steamer *Empress of Asia*, on the same day, near 43° N., 158° E.

Late in the month a LOW of moderate energy lay off the northern coast of the United States. It appears to have caused winds of gale force on only 1 day, the 26th, during which the American steamer *Mojave*, close in off the northern coast of California, experienced winds of force 8 or higher for about 15 hours. The greatest violence attained, force 11, SSE., occurred at about 2 p. m.

Tehuantepecers.—Norther weather in the Gulf of Tehuantepec was more vigorous in February 1935 than in any previous month since January 1928, when there were 11 days with northerly gales. In February there were at least 9 days with gales, distributed as follows: Of force 8 on the 1st, 2d, and 4th; of force 9 on the 17th, 20th, 21st, and 27th; and of force 10 on the 18th and 28th.

Fog.—On the 1st of February, fog blanketed much of the considerable expanse of sea between approximately 43°–51° N., 128°–140° W.; and again on the 3d and 4th was widespread over much of the same area. Fog occurrence diminished toward the westward, but occurred occasionally in several localities. Along the American coast between Vancouver Island and San Francisco, fog was reported on 8 days; between San Diego and Cape San Lucas, on 4 days; and in the Gulf of Tehuantepec, on 2 days.

On the 6th the British steamer *Cruiser* grounded in fog at the entrance to Vancouver Harbor. The passengers were taken ashore, and the ship refloated on the 7th. The British steamer *Princess Alice* grounded on a sand-spit near West Point Light in dense fog on the 9th, but was refloated and proceeded toward Victoria on the 10th.

SEA-SURFACE TEMPERATURE SUMMARY FOR THE EAST CENTRAL GULF OF MEXICO, 1912–33

By GILES SLOCUM

The monthly sea-surface temperatures in a representative area in the eastern part of the Gulf of Mexico are given in the accompanying table. The period covered is from January 1912 to December 1933, inclusive. There are 6 months, as noted in the table, for which no observational data are available. The observations of sea-surface temperature for the years 1917, 1918, and 1919 are few in number, and the average temperatures for this period are therefore given only to whole degrees; the mean temperatures for the balance of the 22-year period are given to tenths of a degree.

The area in which these temperature observations were taken embraces two 1°-squares, namely, between 84° W. and 86° W., and between 25° N. and 26° N.

Monthly and annual sea-surface temperatures in the east central Gulf of Mexico, 1912 to 1933, inclusive

Year [1]	Total number of observations for the year	January	February	March	April	May	June	July	August	September	October	November	December	Annual [2]
1912	240	74.2	72.2	75.7	77.6	79.0	80.9	82.9	83.7	81.9	82.5	78.1	77.8	78.9
1913	202	75.9	73.8	74.3	76.3	77.3	80.1	82.0	82.6	81.5	79.6	76.1	74.8	77.9
1914	178	72.7	69.9	71.0	77.1	78.2	81.1	83.0	84.2	82.4	79.6	76.6	75.1	77.6
1915	142	73.2	73.9	72.3	73.6	79.4	83.4	84.9	84.2	83.0	78.7	78.8	76.0	78.4
1916	111	75.1	72.9	71.9	75.1	77.1	80.8	82.2	82.7	82.6	81.2	78.2	74.5	77.9
1917	49	72	73	73	74	75	81	83	(3)	(3)	80	74	73	[4]76.8
1918	12	(3)	73	76	(3)	78	(3)	84	83	82	(3)	79	71	[4]78.1
1919	68	70	76	76	75	78	80	81	84	83	82	80	77	78.6
1920	154	71.1	71.5	74.0	77.0	79.2	79.8	81.9	82.1	83.3	79.0	76.8	74.7	77.6
1921	249	75.9	74.6	74.9	76.4	76.9	81.5	82.8	83.3	83.3	81.0	78.8	75.5	78.7
1922	341	74.9	73.5	74.5	76.2	79.1	81.3	82.8	83.6	82.6	80.9	79.7	76.2	78.8
1923	370	74.4	73.6	75.6	76.1	78.4	80.6	81.8	82.4	83.3	79.6	74.7	75.0	78.0
1924	451	73.6	72.0	72.7	75.1	77.8	83.1	84.3	85.4	83.4	79.9	76.3	75.5	78.3
1925	455	75.1	73.8	73.2	75.6	78.4	82.1	82.9	84.0	83.8	82.4	78.9	75.3	78.8
1926	536	72.6	73.2	73.1	76.9	77.6	82.1	83.5	84.2	83.3	81.5	78.0	77.4	78.6
1927	594	74.2	76.3	75.2	77.0	79.4	82.6	83.8	85.1	84.0	81.8	79.2	75.9	79.5
1928	571	71.9	72.4	72.3	74.8	77.8	81.7	83.8	84.8	83.5	82.0	78.5	75.9	78.3
1929	536	74.2	74.4	75.9	77.7	79.4	80.9	82.1	83.2	82.7	80.0	78.0	75.9	78.7
1930	522	73.9	74.3	74.0	75.9	78.8	79.9	83.0	84.5	83.3	80.7	78.8	73.2	78.4
1931	433	74.3	72.9	73.3	75.0	78.3	80.1	83.8	84.0	83.6	81.9	78.0	78.6	78.6
1932	335	77.4	76.2	74.4	75.9	77.6	80.6	83.9	85.0	83.2	81.9	79.7	77.3	79.4
1933	459	74.5	75.9	75.6	77.7	80.0	81.4	82.5	83.1	83.4	81.5	78.6	76.9	79.3
Number of years' record		21	22	22	21	22	21	22	21	21	21	22	22	22
Mean (1912-33) [3]		73.9	73.6	74.0	76.0	78.2	81.2	83.0	83.8	83.0	80.9	77.9	75.6	[4]78.4

[1] Values for 1912 to 1919, inclusive, are given to whole degrees, instead of to tenths because of paucity of data.
[2] Computed with monthly values figured to 1 decimal place, and, therefore, not exact means of the figures given here.
[3] No data.
[4] Interpolated values are used for missing months.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, February 1935

[For description of tables and charts, see REVIEW, January, p. 37]

Section	Temperature							Precipitation					
	Section average	Departure from the normal	Monthly extremes: Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Greatest monthly: Station	Amount	Least monthly: Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	50.2	+1.4	Greensboro	82	14	St. Bernard	10	28	4.41	−0.84	Alaga	9.00	Valley Head	1.75
Arizona	48.5	+.2	Wickenburg	88	19	2 stations	−5	26	2.22	+1.01	Natural Bridge	5.65	Gila Bend	.17
Arkansas	45.8	+2.2	Dumas	87	21	Thornburg	8	27	2.44	−.88	Warren	5.23	Rogers	.58
California	47.6	−.7	Ojai	90	18	Ellery Lake	−11	25	2.52	−1.68	Crescent City (near)	9.09	Salinas	.28
Colorado	31.3	+4.1	Holly	83	21	Pearl	−31	25	.57	−.40	Cumbres	3.14	2 stations	T
Florida	60.3	−.3	5 stations	91	[1] 13	Garniers	17	28	2.50	−.57	Panama City	7.26	Homestead	.25
Georgia	49.4	+.6	2 stations	83	[1] 14	Blairsville	10	28	3.50	−1.37	Flat Top	6.22	Augusta	1.13
Idaho	28.6	+.6	3 stations	61	[1] 19	Lifton	−27	25	.72	−.94	Roland	1.85	Arco	.00
Illinois	33.7	−4.3	Mascoutah	76	21	Freeport	−10	27	1.47	−.68	Peoria	2.83	Palestine	.41
Indiana	33.6	+3.1	Shoal	75	21	2 stations	−2	[1] 6	1.00	−1.41	La Porte	6.31	Anderson	.11
Iowa	29.1	+6.6	Keokuk No. 2	64	21	Decorah	−19	27	1.13	+.05	Keokuk No. 2	2.20	Postville	.52
Kansas	38.8	+5.6	Anthony	84	21	Atwood	−10	26	.79	−.22	Tonganoxie	1.77	2 stations	T
Kentucky	40.1	+3.1	Mayfield	73	9	Eubank	5	26	2.35	−1.07	Jenkins	4.23	Anchorage	.53
Louisiana	55.1	+1.3	2 stations	82	[1] 9	Amite	17	28	4.44	−.16	Atchafalaya	8.81	Elizabeth	2.21
Maryland-Delaware	33.2	−.8	3 stations	69	25	Chewsville, Md	−12	7	2.70	−.38	Easton, Md	3.82	Cumberland, Md	1.60
Michigan	21.5	+1.5	Dukes	55	2	Vanderbilt	−37	6	1.45	−.23	Owosso	3.60	Traverse City	.31
Minnesota	22.7	+9.8	2 stations	54	23	Big Falls	−36	26	.28	−.45	Waseca	1.14	7 stations	T
Mississippi	50.6	+1.2	Columbia	83	9	Forest	14	28	3.53	−1.37	Poplarville	7.48	Pontotoc	.51
Missouri	37.4	+4.3	3 stations	80	21	Maryville	0	26	1.55	−.45	Louisiana	3.10	St. Thomas	.77
Montana	29.1	+6.3	Red Lodge (near)	70	2	Hebgen Dam	−30	25	.19	−.49	Heron	1.31	2 stations	.00
Nebraska	34.2	+8.5	Kimball	75	20	Weeping Water	−13	25	.63	−.09	Tekamah	1.64	do	.02
Nevada	37.1	+3.2	2 stations	80	[1] 3	Canyon Creek Ranch.	−14	15	.96	−.06	Searchlight	3.59	Mina	.06
New England	22.2	−.3	Waterbury, Conn	64	16	Pittsburg, N. H	−36	6	2.63	−.52	Peru, Mass	4.35	Presque Isle, Maine	.75
New Jersey	30.1	−.6	Indian Mills	64	25	Runyon	−31	1	2.80	−.81	Camden	4.01	Long Valley	1.74
New Mexico	37.8	+.4	2 stations	85	21	Gavilan (near)	−25	26	.73	+.02	Pinos Altos	3.12	10 stations	.00
New York	22.7	+.4	Jeffersonville	59	25	Wanakena	−35	1	2.24	−.45	South Wales	3.99	Willsboro	.80
North Carolina	43.4	+.7	Willard	79	26	Mount Mitchell	−8	28	2.80	−1.25	Mount Mitchell	4.91	Kinston	1.15
North Dakota	24.0	+13.8	Hettinger	63	1	Eckman	−25	24	.21	−.25	Carson	.95	8 stations	T
Ohio	31.4	+2.1	Ironton	65	25	Medina (near)	−6	7	1.79	−.79	Jefferson	3.80	Oxford	.50
Oklahoma	44.8	+3.8	Mutual	88	21	Hooker	−2	26	1.07	−.28	Idabel	2.12	Boise City	T
Oregon	36.3	+.9	3 stations	79	[1] 1	Danner	−16	16	1.93	−1.16	Brookings	8.50	Enterprise	.13
Pennsylvania	28.9	+.8	Uniontown	66	25	Gouldsboro	−26	7	2.67	−.30	Westford	5.98	Williamstown	1.16
South Carolina	46.9	−.7	Conway	81	26	Cherokee (near)	11	28	2.67	−1.61	Crescent	5.91	Georgetown	1.21
South Dakota	31.4	+12.4	Pine Ridge	71	20	Canton	−12	26	.57	.00	Academy	1.40	Raymond	.02
Tennessee	42.8	+1.6	Covington	75	21	Elkmont	4	28	3.91	−.46	Elkmont	6.92	Union City	1.69
Texas	51.8	+.8	3 stations	90	[1] 21	Vega	1	26	2.25	+.46	Anahuac	6.69	Sunray	.00
Utah	33.8	+3.8	Springdale	76	[1] 19	Laketown	−19	[1] 25	.91	−.32	Bryce Canyon	3.93	Woodruff	.09
Virginia	38.0	+.9	Roanoke	75	22	2 stations	−2	1	2.59	−.51	Rose Hill	4.21	Mount Weather	.99
Washington	37.4	+2.0	2 stations	70	[1] 2	Bumping Lake	−4	14	2.43	−1.25	Spruce	13.63	Ellensburg	.07
West Virginia	34.9	+1.7	Hinton	70	22	Wardenville	−9	1	2.33	−.79	Pickens	4.25	Marlinton	1.20
Wisconsin	21.5	+4.3	Laona	50	3	Rest Lake	−38	25	.92	−.24	Kewaunee	2.56	River Falls	.12
Wyoming	27.2	+4.8	Buffalo	77	21	West Yellowstone	−37	25	.51	−.25	Lander	1.67	Clark	T
Alaska (January)	4.3	+.6	Tree Point	59	[1] 27	Allakaket	−57	[1] 6	2.35	.00	View Cove	15.88	Barrow	.20
Hawaii	68.5	−.4	Hahsione Valley	89	3	Kanalohuluhulu	36	2	11.97	+5.87	2 stations	54.00	Olowalu	.00
Puerto Rico	72.1	−.5	San German	90	25	Guineo Reservoir	44	2	7.95	+5.03	La Mina	19.96	Matrullas Reservoir	2.98

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, February 1935*

[Compiled by Annie E. Small]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
New England	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							24.9	−0.5										74	2.85	−0.4										6.1		
Eastport	76	67	85	29.86	29.95	−0.03	20.2	−1.3	41	15	28	−2	12	12	29	19	15	79	2.27	−1.1	11	7,355	nw.	34	e.	22	7	6	15	6.6	10.2	10.6
Greenville, Maine	1,070	6	40	28.74	29.96	------	13.3	------	38	15	25	−20	1	2	48	----	----	----	2.22	------	12	4,189	nw.	20	----	12	6	7	15	----	23.1	----
Portland, Maine	103	82	117	29.86	29.99	−.03	23.4	−.4	46	15	32	−4	1	15	30	21	15	70	4.30	+.3	10	5,696	n.	24	n.	4	12	9	7	4.5	18.8	20.6
Concord	289	60	----	----	----	----	22.6	−.2	52	25	34	−19	1	11	----	----	----	----	2.80	−.1	8	----	nw.	----	----	----	7	8	13	----	16.5	----
Burlington	403	11	48	29.56	30.03	.00	16.6	−2.8	41	15	26	−17	6	7	34	----	----	----	1.13	−.4	15	6,670	s.	31	s.	14	5	9	14	6.9	7.5	4.3
Northfield	876	12	60	29.02	30.01	−.03	16.2	−.2	45	15	30	−25	1	3	50	13	11	85	1.47	−.8	13	4,554	n.	21	s.	14	4	10	14	7.0	15.2	10.0
Boston	124	336	360	29.86	30.00	−.04	27.8	−1.0	53	25	36	−1	6	20	27	24	17	64	3.26	−.1	9	9,710	w.	37	w.	19	6	8	14	6.6	13.1	3.5
Nantucket	12	14	90	29.98	29.99	−.05	30.6	−.1	48	16	36	15	28	25	20	28	25	81	2.99	−.4	9	9,950	sw.	34	s.	15	9	6	13	6.2	7.3	1.0
Block Island	26	11	46	29.99	30.02	−.04	30.2	−.2	49	15	36	11	6	24	18	28	25	79	3.33	−.3	10	11,370	w.	40	e.	23	8	8	12	6.0	5.9	.5
Providence	160	215	251	29.83	30.02	−.03	28.8	−.2	54	15	37	1	6	21	25	26	19	66	2.64	−1.0	8	7,549	nw.	37	nw.	19	10	9	9	5.2	9.0	2.4
Hartford	159	70	104	------	30.03	−.03	27.8	+.6	50	25	36	−4	1	20	33	----	----	----	3.33	−.5	9	5,581	s.	----	----	----	5	9	14	----	15.3	3.7
New Haven	106	74	153	29.93	30.05	−.02	29.2	+.2	53	16	37	1	1	22	26	26	20	68	3.82	−.2	12	6,061	n.	23	w.	19	6	10	12	6.1	10.1	2.7
Middle Atlantic States							33.7	+0.4										72	2.66	−0.5										6.4		
Albany	97	107	115	29.94	30.05	−.02	24.8	+.7	49	25	34	−11	1	16	32	22	17	74	2.26	−.2	10	5,008	s.	24	sw.	27	3	10	15	7.1	12.5	.7
Binghamton	871	60	68	29.08	30.04	−.04	24.8	+.8	51	15	34	−11	1	16	41	----	----	----	1.94	−.3	15	4,236	nw.	19	sw.	19	4	3	21	8.1	14.3	3.5
New York	314	415	454	29.70	30.05	−.03	31.6	+.3	57	25	39	5	1	24	33	27	20	63	3.01	−.8	9	10,299	nw.	48	nw.	20	4	14	10	6.4	5.2	3.5
Bellefonte	1,050	5	42	28.90	30.05	------	26.2	------	51	15	35	−16	7	17	42	24	21	84	1.77	------	15	------	sw.	----	----	----	4	5	19	7.6	17.1	1.8
Harrisburg	374	94	104	29.65	30.06	−.03	30.4	+.2	53	15	38	−4	7	23	31	27	21	68	2.12	−.8	13	5,271	w.	25	w.	19	4	14	10	6.6	13.4	T
Philadelphia	114	168	367	29.90	30.07	−.03	33.0	−.9	60	25	40	8	1	26	36	29	21	63	3.12	−.2	9	9,040	sw.	31	n.	4	5	11	12	6.1	5.9	1.7
Reading	323	283	306	29.70	30.07	------	31.2	+2.4	59	25	39	0	7	23	39	28	22	69	2.56	−.9	9	7,673	nw.	39	w.	19	3	15	10	6.7	11.0	T
Scranton	806	72	104	29.15	30.05	−.03	27.7	+.4	56	25	35	−1	1	20	33	25	20	74	1.87	−1.2	13	4,865	sw.	24	nw.	19	4	10	14	6.6	11.5	T
Atlantic City	52	37	172	30.00	30.06	−.05	34.2	+.6	57	16	41	7	1	27	23	31	26	75	3.08	−.3	8	10,503	w.	45	se.	14	5	11	12	6.4	2.8	T
Sandy Hook	22	10	57	30.02	30.05	------	31.0	------	54	25	37	10	6	25	29	28	24	76	2.87	−.9	11	9,915	w.	35	n.	27	8	9	11	6.1	7.2	2.0
Trenton	190	88	106	29.85	30.06	------	30.6	−.1	60	25	39	2	1	23	36	28	22	72	2.81	−.5	9	5,586	n.	16	s.	25	5	13	10	6.4	9.7	1.7
Baltimore	123	100	215	29.93	30.07	−.04	35.0	−.4	68	25	43	8	1	27	34	31	25	70	2.74	−.6	9	7,218	sw.	35	sw.	19	9	7	12	5.9	8.1	.5
Washington	112	62	85	29.95	30.08	−.03	35.4	+.1	68	25	44	6	1	27	35	30	24	65	2.37	−.9	11	5,084	nw.	24	nw.	20	7	9	12	5.9	3.5	T
Cape Henry	18	8	54	30.04	30.06	------	41.3	+.1	70	25	49	20	2	33	34	36	32	78	3.54	+.3	7	8,274	n.	40	n.	27	9	7	12	5.7	T	.0
Lynchburg	686	5	----	29.33	30.09	−.02	40.2	−.1	72	22	52	12	28	29	40	----	----	----	3.18	.0	10	----	sw.	----	----	----	2	19	7	----	.1	.0
Norfolk	91	80	125	29.99	30.09	−.02	42.8	+.1	70	22	52	20	28	34	35	37	32	73	3.53	+.3	7	6,745	n.	29	n.	26	8	8	12	6.1	T	.0
Richmond	144	11	52	29.94	30.10	−.01	39.6	.0	69	25	50	11	1	29	36	34	29	74	2.13	−1.0	8	5,774	sw.	27	w.	25	9	6	13	5.5	.1	.0
Wytheville	2,304	49	55	------	30.08	−.04	36.8	+1.7	65	22	46	12	27	27	36	----	----	74	2.17	−.8	8	5,978	w.	27	w.	15	8	8	12	----	T	.0
South Atlantic States							47.8	0.0										73	2.66	−1.6										4.9		
Asheville	2,253	89	104	27.70	30.13	.00	40.4	+1.9	71	22	51	13	28	30	37	34	28	71	2.05	−1.1	8	6,714	nw.	29	nw.	26	9	7	12	6.1	T	.0
Charlotte	779	63	86	29.25	30.10	−.02	44.0	+.1	71	22	54	19	1	34	32	38	32	69	3.35	−.8	8	5,633	sw.	26	sw.	22	14	1	13	5.2	.0	.0
Greensboro	886	6	56	29.12	30.10	------	39.6	------	71	22	51	14	28	28	38	34	29	75	2.52	------	9	6,109	sw.	28	nw.	3	8	7	13	5.8	.0	.0
Hatteras	11	5	50	30.06	30.07	−.04	48.2	+.8	68	25	54	26	28	42	33	45	42	85	2.07	−2.0	8	9,913	n.	36	n.	27	15	6	7	4.3	.0	.0
Raleigh	376	103	146	29.67	30.09	−.02	43.9	+.7	73	22	54	16	1	34	31	38	34	74	2.73	−1.2	7	6,460	sw.	30	nw.	20	10	6	12	5.3	T	.0
Wilmington	72	73	107	30.02	30.10	−.02	48.6	+.7	74	26	59	22	1	39	34	42	38	75	1.74	−1.5	7	6,511	n.	29	sw.	14	12	5	11	4.9	.0	.0
Charleston	48	11	92	30.06	30.11	−.01	51.2	−1.2	73	10	60	26	1	43	27	45	39	72	1.93	−1.0	7	7,143	sw.	27	e.	6	12	4	12	5.0	.0	.0
Columbia, S. C	351	41	57	29.72	30.11	.00	47.3	−.9	72	22	57	20	28	37	33	41	35	69	1.37	−2.4	9	5,295	ne.	21	s.	26	14	3	11	4.7	.0	.0
Greenville, S. C	1,039	139	----	----	----	----	43.9	+.6	68	23	54	17	28	34	37	----	----	----	2.50	−2.7	9	----	nw.	----	----	----	15	3	10	----	.0	.0
Augusta	182	62	77	29.91	30.11	−.01	48.4	−1.5	74	25	59	22	28	38	35	42	34	64	1.13	−3.0	7	4,460	nw.	30	nw.	20	13	4	11	4.9	.0	.0
Savannah	65	73	152	30.05	30.12	.00	53.6	−.4	78	14	64	27	1	43	30	46	41	73	2.12	−1.0	6	7,677	w.	32	w.	20	14	6	8	4.1	.0	.0
Jacksonville	43	86	110	30.08	30.14	+.02	56.8	−1.2	83	14	67	27	28	46	29	49	44	74	1.69	−1.3	5	5,825	nw.	30	sw.	26	15	9	4	3.6	.0	.0
Florida Peninsula							66.0	−0.5										76	0.75	−1.1										3.7		
Key West	22	10	64	30.07	30.10	+.03	69.3	−1.2	83	16	75	50	28	64	18	63	60	79	.40	−.9	4	7,155	n.	35	nw.	27	15	10	3	3.2	.0	.0
Miami	25	124	168	30.09	30.12	+.02	66.6	−.5	81	16	74	38	28	59	30	60	56	74	.31	−1.5	5	7,278	se.	25	s.	15	14	7	7	4.4	.0	.0
Tampa	35	88	197	30.00	30.14	+.04	62.0	+.1	83	12	72	30	28	52	30	54	50	76	1.55	−1.0	8	7,537	n.	29	sw.	16	14	10	4	3.5	.0	.0
Titusville	43	5	36	30.06	30.11	------	60.6	------	89	14	73	30	28	48	36	----	----	----	1.33	------	5	------	nw.	----	----	----	11	10	7	----	.0	.0
East Gulf States							51.3	+0.1										73	4.12	−0.7										4.8		
Atlanta [1]	1,173	128	135	29.07	30.12	.00	45.0	−.3	72	25	54	18	28	36	35	39	34	73	4.37	−.4	9	7,123	nw.	34	nw.	27	9	9	10	5.3	T	.0
Macon	370	79	87	29.73	30.14	+.02	48.7	−.6	75	25	60	20	28	38	37	41	34	66	1.91	−2.5	10	5,153	nw.	34	nw.	20	14	4	10	4.6	.0	.0
Thomasville	273	49	58	29.85	30.15	+.03	54.0	−1.0	76	13	65	22	28	43	32	46	44	77	4.85	+.4	9	------	sw.	----	----	----	14	3	11	----	.0	.0
Apalachicola	35	11	51	30.10	30.14	------	55.2	------	72	26	62	27	28	48	26	50	----	----	6.04	+2.1	7	----	e.	----	----	----	13	4	11	----	.0	.0
Pensacola	56	149	185	30.08	30.14	+.03	54.5	−.7	70	25	62	26	28	47	35	50	46	79	3.11	−1.2	8	8,603	ne.	30	nw.	14	15	3	10	4.1	.0	.0
Anniston	741	9	----	----	----	----	47.6	+1.8	71	22	58	16	28	37	42	----	----	----	4.40	−1.0	11	----	nw.	----	----	----	13	1	14	----	T	.0
Birmingham	700	11	48	29.35	30.14	+.02	48.0	.0	72	25	57	19	28	39	30	41	36	70	5.28	+.2	11	5,525	nw.	26	se.	13	11	4	13	5.6	T	.0
Mobile	57	125	161	30.07	30.13	+.02	54.7	.0	75	13	63	25	28	46	40	48	44	77	3.56	−1.8	7	6,739	nw.	31	n.	26	14	6	8	4.4	.0	.0
Montgomery	218	92	105	29.89	30.15	+.03	51.3	−.3	77	25	61	24	28	42	35	44	39	71	5.62	+.2	11	5,471	nw.	22	nw.	20	14	2	12	4.7	T	.0
Meridian	375	67	92	29.73	30.14	+.03	50.6	+1.0	77	13	61	20	28	40	36	44	39	72	3.72	−1.7	10	4,792	nw.	20	nw.	26	13	5	10	4.8	T	.0
Vicksburg	247	65	73	29.88	30.15	+.05	52.0	+.2	74	21	61	24	27	43	32	46	41	72	2.88	−1.9	11	5,416	n.	28	s.	9	13	2	13	5.0	.0	.0
New Orleans	53	76	84	30.08	30.14	+.05	58.2	+.9	80	9	66	32	28	50	28	51	46	72	3.64	−.6	8	4,766	nw.	18	nw.	26	14	3	11	4.5	.0	.0
West Gulf States							52.6	+1.1										70	2.57	+0.1										4.6		
Shreveport	249	92	227	29.87	30.15	+.06	52.2	+1.3	78	21	62	25	27	42	34	45	40	70	3.33	.0	8	7,883	ne.	33	nw.	25	12	6	10	5.0	.0	.0
Bentonville	1,303	11	44	28.83	30.12	+.02	41.2	+2.7	73	21	51	13	27	32	33	----	----	----	1.09	−1.1	6	5,031	n.	21	sw.	21	10	5	13	----	.3	.0
Fort Smith	457	79	94	29.64	30.13	+.03	45.0	+2.2	77	21	54	19	27	36	38	38	31	67	.70	−1.9	7	5,935	nw.	32	sw.	21	11	7	10	5.3	.2	.0
Little Rock	357	94	102	29.76	30.15	+.04	46.4	+1.5	75	21	56	21	27	37	40	40	33	66	2.40	−1.4	7	6,278	n.	29	sw.	21	8	9	11	5.6	T	.0
Austin	605	136	148	29.49	30.13	------	54.6	+1.2	78	3	66	23	27	44	37	47	40	67	3.86	+1.5	7	6,052	n.	32	n.	8	16	1	11	4.4	.0	.0
Brownsville	57	88	96	30.03	30.09	------	61.6	−1.0	80	9	71	35	27	52	35	54	49	73	.27	−.9	6	7,883	se.	37	s.	24	14	4	10	4.5	.0	.0
Corpus Christi	20	11	78	30.10	30.12	+.07	58.6	+.2	80	7	66	36	27	51	29	53	50	79	.86	−.6	5	7,402	n.	31	s.	24	14	2	12	4.7	.0	.0
Dallas	512	220	227	29.58	30.14	------	49.6	------	76	24	59	22	25	40	36	43	36	65	2.16	−.1	9	8,472	n.	36	s.	21	13	6	9	4.6	.2	.0
Fort Worth	670	92	110	29.43	30.15	+.08	49.6	+1.3	78	21	60	22	26	40	40	----	----	----	3.29	+1.5	9	7,099	n.	35	s.	24	15	4	9	4.1	.2	.0
Galveston	54	106	114	30.06	30.14	+.07	56.8	+.5	74	3	63	33	26	51	28	52	49	81	5.00	+2.2	7	7,247	s.	30	n.	26	15	3	10	4.1	.0	.0
Houston	138	292	314	29.99	30.15	------	56.7	+.8	78	20	66	31	26	48	33	----	----	----	3.78	+.6	7	8,108	s.	35	nw.	8	13	5	10	4.3	.0	.0
Palestine	510	64	72	29.60	30.15	+.07	52.2	+1.0	76	21	62	25	27	42	39	46	40	70	3.57	+.5	8	5,875	s.	29	s.	24	14	5	9	4.4	T	.0
Port Arthur	34	58	66	30.10	30.13	------	56.7	------	76	3	65	29	27	48	31	----	----	----	3.92	+.4	9	5,983	n.	28	nw.	26	11	10	7	4.9	.0	.0
San Antonio	693	242	301	29.38	30.11	+.06	56.2	+.8	80	19	66	28	27	46	34	48	41	64	1.87	+.2	5	8,189	n.	37	n.	25	14	6	8	4.3	.0	.0

TABLE 1.—*Climatological data for Weather Bureau stations, February 1935*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								0–10	*In.*	*In.*
							37.6	+1.5										74	2.11	−1.3										7.0		
Chattanooga	762	71	214	29.30	30.13	0.00	45.6	+1.5	68	22	54	18	28	38	34	39	33	67	4.38	−0.5	11	6,169	w.	27	w.	19	9	6	13	6.0	0.1	0.0
Knoxville	995	66	84	29.04	30.12	.00	42.6	+.7	67	22	51	16	28	34	34	38	33	75	4.72	+.2	10	4,459	w.	24	w.	19	9	7	12	6.1	.2	.0
Memphis	399	78	86	29.70	30.13	+.02	45.2	+.9	73	21	53	20	27	37	36	41	36	73	2.06	−2.3	7	5,694	sw.	22	nw.	22	9	5	14	5.8	T	.0
Nashville	546	168	191	29.54	30.14	+.02	42.6	+1.0	68	21	51	16	27	34	39	38	33	73	3.63	−.5	8	7,109	nw.	30	nw.	19	5	9	14	6.7	1.5	T
Lexington	989	5																													
Louisville	525	188	234	29.52	30.12	+.01	38.1	+.9	65	21	46	15	27	30	38	34	29	73	1.36	−2.2	6	7,868	s.	37	s.	21	11	7	10	5.9	T	.0
Evansville	431	76	116	29.64	30.12	+.01	39.1	+2.8	67	21	47	14	27	31	35	34	30	73	1.62	−1.6	7	7,479	sw.	34	sw.	21	9	4	15	6.2	1.1	.0
Indianapolis	822	194	230	29.18	30.09	−.01	33.0	+1.9	62	14	41	7	6	26	34	29	24	72	.20	−2.5	5	8,312	sw.	37	nw.	18	3	8	17	7.8	T	.0
Terre Haute	575	96	129	29.45	30.09		35.5		62	14	43	11	27	28	35	31	27	73	.50	−2.1	5	7,259	sw.	29	sw.	18	7	5	16	6.8	T	.0
Cincinnati	627	11	51	29.40	30.10	.00	35.2	+2.4	59	24	43	9	6	27	35	31	27	77	1.08	−1.9	9	6,347	sw.	27	w.	18	3	7	18	7.7	.3	.0
Columbus	822	90	210	29.18	30.08	−.01	32.4	+1.7	53	25	39	8	6	26	24	30	26	77	1.39	−1.3	9	7,176	s.	38	sw.	15	1	8	19	8.3	1.7	.0
Dayton	900	58	153	29.10	30.08		33.2	+1.8	56	14	40	4	6	26	29				1.06	−1.6	8	6,773	sw.	31	sw.	15	2	5	21		.1	.0
Elkins	1,947	59	78	27.98	30.12	+.02	33.8	+2.2	67	25	43	3	27	24	40	29	26	80	2.81	−.3	19	5,014	w.	28	sw.	15	1	7	20	8.3	11.2	.4
Parkersburg	637	77	84	29.44	30.12	+.02	35.2	+1.0	63	25	43	10	27	27	31	32	28	78	1.68	−1.4	11	4,972	nw.	28	w.	19	5	5	18	7.6	2.9	T
Pittsburgh	842	353	410	29.14	30.07	−.02	33.2	+.9	61	25	40	8	27	26	27	30	26	76	3.00	+.4	18	7,560	sw.	36	w.	19	3	4	21	8.0	13.3	2.0
Lower Lake Region							25.0	0.0										79	2.04	−0.4									8.0		
Buffalo	768	243	280	29.17	30.04	−.02	23.8	−.5	45	15	30	3	27	18	25	22	19	83	3.00	.0	20	11,242	sw.	50	sw.	2	3	6	19	8.0	15.6	2.2
Canton	448	10	61	29.51	30.02		15.2	−2.8	42	15	25	−20	1	5	45				2.08	−.2	19	5,978	w.	29	sw.	2	5	7	16	7.0	15.2	6.7
Ithaca	836	77	100	29.10	30.04		24.9	+.4	51	15	34	−8	6	16	37	22	18	76	1.31	−.7	16	6,416	nw.	27	nw.	19	3	5	20	8.1	9.5	1.4
Oswego	335	71	85	29.66	30.04	−.02	23.0	−.9	50	15	30	−5	1	16	33	21	16	76	1.47	−1.2	15	7,470	s.	26	n.	3	2	2	24	8.6	12.7	3.8
Rochester	523	86	102	29.45	30.05	−.01	24.4	−.2	52	15	31	2	1	18	31	22	17	74	2.40	−.3	17	6,566	w.	29	w.	2	3	8	17	7.8	14.1	2.5
Syracuse	596	65	79	29.38	30.05	−.02	24.5	+.7	52	15	32	−6	6	16	34				2.25	−.5	18	5,092	w.	21	w.	19	2	11	15	7.5	12.5	.5
Erie	714	130	166	29.26	30.05	−.02	26.0	−.9	51	15	33	1	6	20	26	24	21	80	2.60	.0	17	9,203	w.	38	se.	14	5	5	18	7.5	15.6	.5
Cleveland	762	267	337	29.20	30.05	−.02	28.6	+1.2	53	15	35	6	6	22	34	27	24	81	3.26	+.8	20	9,764	w.	48	n.	5	2	5	21	8.2	20.9	T
Sandusky	629	5	67	29.37	30.08	+.01	28.8	+1.4	52	15	35	8	27	23	31				1.65	−.5	16	7,036	sw.	25	ne.	22	1	6	21	8.5	8.9	T
Toledo	628	79	87	29.37	30.08	+.01	27.2	−.1	50	15	33	3	6	21	34	26	22	78	1.52	−.5	15	7,155	w.	25	nw.	19	2	8	18	8.1	8.8	T
Fort Wayne	857	69	84	29.12	30.08		28.8	+3.0	50	14	35	4	6	22	33	27	24	82	1.20	−1.2	12	6,979	nw.	32	w.	18	1	6	21	8.6	5.4	.0
Detroit [1]	626	5	78	29.36	30.06	.00	24.4	−.9	46	25	32	−3	7	17	34	23	20	82	1.75	−.4	13	7,180	sw.	29	sw.	2	2	7	19	7.7	14.0	T
Upper Lake Region							22.0	+3.3										82	1.24	−0.6									7.5		
Alpena	609	13	89	29.38	30.07	+.04	19.6	+1.6	42	2	28	−8	27	11	34	18	14	81	1.02	−.7	13	7,086	nw.	27	e.	4	7	8	13	6.4	13.0	8.0
Escanaba	612	54	60	29.40	30.10	+.04	19.6	+4.2	52	2	28	−15	6	11	34	17	14	82	.51	−1.0	5	7,201	n.	34	n.	3	5	9	14	6.8	6.3	9.0
Grand Rapids	707	70	244	29.27	30.07	+.02	25.6	+1.9	43	14	32	−1	26	19	25	23	19	77	1.91	−.3	12	7,536	sw.	32	ne.	24	2	6	20	8.5	21.2	5.4
Lansing	878	6	88	29.08	30.06		22.3	−.6	42	14	30	−1	26	14	27	22	21	94	1.99	+.1	14	6,340	sw.	23	nw.	20	5	3	20	8.0	17.1	2.2
Ludington	637	5	54																												
Marquette	734	77	111	29.24	30.08	+.03	21.6	+5.3	54	2	28	1	27	15	26	19	17	85	.72	−1.2	11	7,108	w.	36	nw.	3	6	8	14	6.9	6.9	11.6
Sault Sainte Marie	614	11	52	29.36	30.10	+.07	13.6	+1.0	39	2	24	−17	26	3	43	12	10	85	.66	−1.3	13	5,170	se.	32	nw.	2	8	6	14	6.3	8.0	13.8
Chicago	673	7	131	29.34	30.09	+.01	29.6	+3.3	46	14	35	4	27	25	20	27	24	77	1.59	−.6	12	7,511	sw.	32	nw.	18	1	7	20	8.5	6.7	.9
Green Bay	617	109	141	29.40	30.09	+.03	21.2	+3.8	42	2	28	−9	27	14	35	19	16	80	1.28	−.3	9	7,544	sw.	41	ne.	25	3	2	23	8.4	14.8	6.8
Milwaukee	681	97	221	29.32	30.09	+.03	26.6	+3.8	41	2	32	1	27	21	22	25	20	75	2.24	+.4	12	9,246	n.	35	ne.	24	4	3	21	8.3	17.0	9.0
Duluth	1,133	5	47	28.82	30.10	+.02	19.8	+8.4	44	2	27	−8	26	12	26	18	15	85	.45	−.6	5	8,439	nw.	50	nw.	3	5	8	15	7.0	5.2	9.8
North Dakota							23.7	+15.8										83	0.18	−0.4									5.8		
Moorhead, Minn	940	50	58	29.08	30.14	+.03	23.8	+15.7	46	13	32	−6	25	16	32	22	19	84	.25	−.4	5	6,461	s.	27	n.	18	4	8	16	7.2	3.0	T
Bismarck	1,674	8	57	28.29	30.14	+.02	27.6	+17.3	58	1	38	−5	26	17	39	24	20	77	.29	−.2	4	5,633	nw.	32	nw.	19	13	5	10	5.1	3.9	.0
Devils Lake	1,478	11	44	28.49	30.14	+.03	21.3	+16.2	43	12	30	−11	24	12	38	20	18	89	.14	−.4	4	6,145	w.	20	nw.	18	8	6	14	6.2	1.0	T
Grand Forks	833	12	67				21.6		41	22	30	−9	24	13	36	20			.01		1		nw.	34	nw.	18	10	4	14		.1	.5
Williston	1,878	41	48	28.11	30.17	+.06	22.0	+13.9	47	22	31	−8	24	13	39	20	17	83	.02	−.4	1	4,835	w.	26	nw.	18	12	8	8	4.9	.3	T
Upper Mississippi Valley							30.6	+5.7										80	1.37	−0.3									7.4		
Minneapolis	918	102	208	29.09	30.11		25.5	+9.6	46	23	32	−3	26	19	29	23	19	76	.21	−.7	2	7,658	n.	36	nw.	19	3	8	17	7.5	.8	T
La Crosse	714	11	48	29.31	30.11	+.03	25.0	+5.8	45	2	32	−14	27	18	41	23	20	81	.71	−.4	5	4,139	s.	22	w.	19	3	3	22	8.2	6.1	4.8
Madison	974	70	78	29.01	30.11	+.04	24.1	+5.0	41	2	30	−3	28	18	27	23	21	88	1.52	.0	8	6,704	n.	36	n.	25	4	3	21	8.1	11.6	8.5
Charles City	1,015	10	51	29.00	30.13	+.03	25.5	+8.4	43	23	32	−10	26	19	37	24	21	82	1.03	−.1	4	5,374	n.	23	ne.	25	6	5	17	6.6	8.2	5.2
Davenport	606	66	161	29.44	30.13	+.03	29.9	+5.0	47	24	36	3	27	24	25	27	24	81	1.27	−.3	9	6,977	ne.	30	nw.	18	4	6	18	7.8	2.1	.8
Des Moines	861	5	99	29.19	30.13	+.02	30.6	+6.9	49	23	37	0	26	24	30	28	25	81	1.32	+.2	8	6,930	n.	32	w.	19	5	7	16	6.9	8.4	2.0
Dubuque	700	60	79	29.33	30.12	+.03	27.2	+5.0	44	2	34	−10	27	21	37	25	21	78	1.54	+.2	8	4,744	nw.	23	nw.	19	4	4	20	7.9	9.2	6.0
Keokuk	614	64	78	29.43	30.14	+.03	33.2	+5.1	61	21	39	9	26	27	31	30	26	79	1.79	+.2	8	5,835	sw.	26	nw.	18	4	6	18	7.5	1.0	.0
Cairo	358	87	93	29.73	30.12	.00	41.8	+3.3	72	21	50	17	27	34	36	36	31	70	1.34	−1.8	5	7,254	n.	30	sw.	21	6	5	17	6.9	T	.0
Peoria	609	11	45	29.43	30.12	+.02	31.4	+5.5	54	21	38	7	27	25	29	29	26	85	2.83	+.8	8	5,479	nw.	23	ne.	22	6	6	16	7.1	1.2	.0
Springfield, Ill	636	5	191	29.40	30.10	.00	34.6	+5.1	63	21	41	11	27	28	34	31	28	82	1.57	−.8	6	7,971	w.	28	sw.	25	3	8	17	7.5	T	.0
St. Louis	568	265	303	29.48	30.11	.00	38.5	+4.0	79	21	47	13	27	30	46	33	29	73	1.27	−1.3	7	8,506	nw.	43	sw.	24	8	5	15	6.5	.1	.0
Missouri Valley							35.4	+6.3										76	0.98	−0.3									5.8		
Columbia, Mo	784	6	84	29.26	30.12	+.01	36.8	+5.1	76	21	44	11	26	30	40				.85	−1.2	5	6,409	sw.	27	sw.	25	4	11	13	6.6	T	.0
Kansas City [1]	750	32	45	29.35	30.13	+.02	36.8	+5.6	75	21	44	11	26	29	35	33	29	76	1.34	−.4	6	7,190	sw.	34	nw.	25	8	7	13	6.3	.2	.0
St. Joseph	967	11	49	29.06	30.13		35.2		65	21	43	7	26	28	33	31	27	77	1.10	−.3	4	6,062	n.	32	nw.	19	12	5	11	5.1	T	.0
Springfield, Mo	1,324	98	104	28.68	30.12	+.01	39.2	+4.0	73	21	48	10	26	31	31	34	30	78	.99	−1.4	7	7,640	nw.	32	sw.	21	10	8	10	5.6	.7	.0
Iola	984	11	50	29.07	30.15	+.05	40.2	+7.0	77	21	50	11	26	30	41				1.58	−.1	7		n.					7	10	11		T	.0
Topeka	987	65	87				36.7	+5.7	74	21	45	10	26	28	40				1.09	−.4	6	6,511	n.	28	nw.	25	11	5	12	5.8	.1	.0
Lincoln	1,189	11	81	28.82	30.14	+.04	34.7	+8.6	62	2	44	1	26	26	35	30	26	75	.87	−.1	6	6,880	n.	41	n.	24	9	9	10	5.7	5.9	T
Omaha	1,105	170	200	28.92	30.14	+.03	33.8	+8.3	56	2	42	2	26	26	34	30	25	74	.91	.0	6	7,768	n.	53	n.	24	10	7	11	5.6	6.6	2.0
Valentine	2,598	47	54	27.37	30.17	+.08	33.0	+11.6	64	1	44	−3	25	22	40	28	23	73	.45	−.1	6	6,386	w.	26	nw.	14	10	8	10	5.5	3.7	.0
Sioux City	1,138	64	106	28.88	30.14	+.02	31.9	+10.9	55	23	40	−2	26	24	33	28	25	78	1.34	+.5	8	6,489	nw.	37	nw.	18	6	10	12	6.5	7.4	.8
Huron	1,306	60	74	28.71	30.15	+.03	30.6	+16.3	53	2	39	0	25	22	34	27	24	80	.31	−.2	4	6,505	se.	26	ne.	23	11	7	10	5.1	1.8	.0

[1] Observations taken at airport.

TABLE 1.—*Climatological data for Weather Bureau stations, February 1935*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Northern Slope	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								0–10	*In.*	*In.*
							30.6	+8.8										68	0.48	−0.2										5.2		
Billings	3,570	17	31																												
Havre	2,505	11	67	27.46	30.19	+.12	28.2	+14.6	54	1	39	−2	11	18	35	24	21	79	.30	−.2	3	5,459	e.	32	sw.	17	9	10	9	4.6	4.4	.0
Helena	4,124	85	111	25.89	30.21	+.10	30.7	+7.7	53	20	39	11	25	23	30	26	19	63	.16	−.5	3	4,650	sw.	27	sw.	15	8	7	13	6.2	3.8	.0
Kalispell	2,973	48	56	27.09	30.25	+.17	27.8	+4.5	45	18	35	10	26	21	27	26	24	86	.25	−.9	5	3,071	nw.	22	sw.	22	5	4	19	7.2	.4	.0
Miles City	2,371	48	55	27.57	30.20	+.11	33.2	+16.4	62	17	44	3	25	23	37	28	23	71	.05	−.4	2	3,604	s.	22	nw.	18	9	15	4	4.8	T	.0
Rapid City	3,259	50	58	26.67	30.19	+.11	35.0	+11.6	68	1	46	0	25	24	36	28	20	59	.50	.0	6	5,810	n.	31	n.	23	10	9	9	5.3	4.1	T
Cheyenne	6,094	50	71	24.02	30.15	+.12	32.8	+5.5	66	20	45	−8	25	20	39	25	15	54	.69	.0	5	7,500	nw.	38	w.	21	10	9	9	5.0	8.6	T
Lander	5,372	60	68	24.70	30.22	+.14	27.9	+5.4	65	20	41	−14	26	15	39	23	16	67	1.67	+1.0	3	3,114	sw.	34	w.	21	13	8	7	4.5	14.2	8.0
Sheridan	3,790	10	47	26.16	30.18	.....	32.0	.....	64	17	46	−3	25	18	41	26	19	65	.35	−.4	4	3,521	nw.	27	nw.	21	10	8	10	5.1	3.1	.0
Yellowstone Park	6,241	11	48	.....	30.30	+.20	24.2	+4.6	48	20	35	−12	25	13	37	.....	.....	70	.48	−.8	7	5,137	s.	28	sw.	28	7	7	14	.....	9.9	6.5
North Platte	2,821	11	51	27.14	30.15	+.08	35.4	+8.8	67	4	48	−1	26	23	42	28	21	68	.31	−.2	4	5,507	w.	27	ne.	24	9	8	11	6.0	2.4	T
Middle Slope							39.5	+5.8										60	0.80	0.0									4.8		
Denver	5,292	106	113	24.76	30.12	+0.11	38.0	+5.3	75	20	50	2	25	26	44	29	13	43	0.90	+0.4	4	5,562	s.	37	nw.	23	12	8	8	4.9	9.6	T
Pueblo	4,685	80	86	25.34	30.11	+.11	38.8	+5.9	75	4	54	4	26	24	56	29	17	50	.43	.0	5	4,500	nw.	32	w.	21	14	10	4	4.1	4.2	0.0
Concordia	1,392	50	58	28.65	30.17	+.08	37.3	+7.5	70	2	47	5	26	27	40	31	26	71	.67	−.2	7	6,013	n.	26	n.	24	9	9	10	5.7	1.8	.0
Dodge City	2,509	10	86	27.49	30.16	+.10	39.8	+6.6	77	21	52	6	26	28	46	32	23	61	.55	−.2	7	8,247	n.	37	nw.	14	13	9	6	4.1	1.4	.0
Wichita	1,358	85	93	28.67	30.14	+.06	39.4	+5.0	79	21	48	11	26	30	49	34	27	67	1.39	+.1	6	7,547	n.	35	sw.	23	9	7	12	5.3	.2	.0
Oklahoma City	1,214	10	47	28.84	30.15	+.08	43.9	+4.3	79	21	55	14	26	33	56	36	30	67	.86	−.2	5	7,145	n.	30	nw.	24	12	5	11	5.0	T	.0
Southern Slope							48.1	+2.2										56	1.12	+0.4									4.2		
Abilene	1,738	10	52	28.30	30.14	+.09	48.4	+1.2	79	21	60	19	26	37	47	40	30	59	2.95	+1.9	8	6,490	n.	30	sw.	24	14	5	9	4.5	T	.0
Amarillo	3,676	10	49	26.33	30.12	+.10	43.3	+5.2	80	21	56	9	25	31	41	33	21	51	.22	−.5	1	6,369	sw.	27	n.	25	12	7	9	4.8	1.2	.0
Big Spring	2,537	5	62	27.48	30.15	.....	46.8	.....	80	21	59	17	26	34	41	37	28	58	1.25	.....	6	.....	s.	.....	.....	.....	15	7	6	3.9	T	.0
Del Rio	944	64	71	29.09	30.09	+.09	56.4	+.4	86	24	67	31	27	46	35	48	40	64	.79	+.2	8	6,166	nw.	30	nw.	16	17	2	9	3.9	.0	.0
Roswell	3,566	75	85	26.45	30.11	+.13	44.4	+1.9	79	21	58	15	25	30	46	35	22	48	.53	.0	5	5,321	s.	32	ne.	24	14	6	8	3.9	.7	.0
Southern Plateau							46.8	+2.0										56	0.95	+0.4									4.2		
El Paso	3,778	152	175	26.27	30.11	+.16	48.6	−.4	75	20	60	20	26	37	34	38	25	47	.47	+.1	4	6,462	e.	35	w.	24	17	7	4	3.2	1.3	.0
Albuquerque	4,972	5	39	25.12	30.12	.....	38.6	.....	67	21	53	13	26	25	43	31	22	58	.20	−.1	6	4,826	n.	34	sw.	24	12	7	9	4.9	1.8	.0
Santa Fe	7,013	38	53	23.27	30.12	+.14	34.5	+1.4	59	20	45	7	16	24	36	29	23	65	.56	−.2	9	3,811	e.	20	n.	21	11	6	11	4.8	7.5	.0
Flagstaff	6,907	10	59	23.36	30.03	+.03	33.3	+2.5	60	20	45	1	25	22	42	29	.....	72	1.62	.....	10	5,443	sw.	26	sw.	23	10	6	12	.....	.7	T
Phoenix	1,108	10	107	28.89	30.06	+.07	57.9	+2.8	83	20	70	35	27	46	38	47	36	52	3.18	+2.4	7	3,954	e.	25	w.	23	11	9	8	4.6	.0	.0
Yuma	141	9	54	29.91	30.06	+.06	61.1	+2.5	85	20	72	41	27	50	37	49	35	43	.66	+.2	6	4,467	n.	35	w.	23	15	9	4	3.4	.0	.0
Independence	3,957	5	26	26.05	30.13	+.07	45.4	+3.2	75	20	58	21	26	33	38	36	.....	.....	.62	−.2	4	.....	n.	.....	.....	.....	12	11	5	.....	.0	.0
Middle Plateau							37.4	+4.0										62	0.68	−0.3									4.8		
Reno	4,527	61	76	25.55	30.16	+.08	39.6	+4.0	67	19	50	17	10	29	37	33	26	62	.56	−.6	5	4,314	w.	30	sw.	20	8	10	10	5.6	2.1	.0
Tonopah	6,090	12	30	.....	.....	.....	36.7	.....	59	19	44	11	25	29	24	30	21	57	.71	.....	6	.....	se.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnemucca	4,344	18	56	25.72	30.19	+.10	36.2	+2.7	63	20	48	11	15	25	37	32	27	72	.96	.0	7	5,421	ne.	21	w.	20	12	5	10	4.7	5.5	.0
Modena	5,473	10	46	24.67	30.10	+.06	35.8	+4.8	67	19	48	8	26	24	43	30	21	63	.70	−.2	8	5,718	sw.	30	sw.	23	12	4	12	4.9	.9	.0
Salt Lake City	4,357	86	210	25.73	30.19	+.11	37.4	+3.6	62	20	46	18	15	29	27	32	26	66	.72	−.8	8	4,009	nw.	29	ne.	24	12	6	10	5.1	6.1	.0
Grand Junction	4,602	60	68	25.47	30.11	+.07	37.8	+4.9	62	19	50	14	26	26	35	30	20	53	.46	−.1	5	3,981	se.	24	sw.	23	15	7	6	3.8	3.2	.0
Northern Plateau							35.0	+2.4										74	0.59	−0.8									6.6		
Baker	3,471	48	53	26.60	30.28	+.16	31.8	+2.8	49	19	40	14	12	24	28	29	25	76	.49	−.7	6	4,804	se.	20	nw.	24	8	8	12	6.1	4.0	.0
Boise	2,739	79	87	27.36	30.30	+.18	33.2	−1.6	55	28	40	18	12	27	21	30	26	76	1.00	−.4	9	3,387	se.	21	nw.	24	3	7	18	7.8	9.9	.0
Pocatello	4,477	60	68	25.60	30.25	+.15	30.6	+1.7	52	20	39	10	17	22	29	27	21	69	.34	−.9	6	4,950	nw.	32	w.	20	8	10	10	5.6	1.8	.0
Spokane	1,929	101	110	28.14	30.24	+.15	35.6	+4.3	50	2	42	18	9	29	21	33	29	76	.59	−1.2	5	3,831	ne.	24	w.	22	5	9	14	6.6	1.5	.0
Walla Walla	991	57	65	29.13	30.23	+.12	39.8	+2.7	57	27	46	27	11	34	23	37	32	76	.83	−.9	7	3,307	s.	25	w.	22	7	4	17	7.2	.3	.0
Yakima	1,076	58	67	29.05	30.23	.....	38.7	+4.2	54	27	48	21	10	30	26	35	30	73	.28	−.7	5	2,632	nw.	21	sw.	22	6	10	12	6.3	.7	.0
North Pacific Coast Region							46.3	+4.2										76	3.85	−1.6									7.3		
North Head	211	11	56	29.88	30.12	+.06	47.6	+4.6	63	2	52	36	24	43	17	44	40	75	4.86	−2.6	16	9,308	e.	54	se.	12	5	10	13	6.4	.0	.0
Seattle	125	90	321	30.00	30.13	+.07	45.0	+3.9	60	19	51	29	10	39	21	42	37	75	2.04	−1.8	15	5,205	se.	40	s.	22	5	10	13	7.0	.0	.0
Tatoosh Island	86	10	54	30.00	30.10	+.10	46.0	+5.0	63	2	49	39	24	43	16	43	41	84	8.26	−1.2	15	12,595	e.	46	e.	6	7	4	17	6.7	.0	.0
Medford	1,329	29	58	28.73	30.17	.....	43.9	.....	68	2	54	23	25	34	36	40	35	73	1.94	−.4	11	3,331	n.	32	se.	26	1	4	23	8.4	.2	.0
Portland, Oreg	153	68	106	30.00	30.16	+.08	46.2	+4.1	58	4	52	29	25	40	23	42	37	72	3.17	−2.2	14	4,025	se.	22	sw.	22	3	7	18	7.3	.0	.0
Roseburg	510	45	76	29.60	30.16	+.06	46.8	+3.4	67	2	56	27	25	38	32	43	39	77	2.84	−1.6	13	2,476	sw.	18	sw.	12	1	7	20	8.2	.0	.0
Middle Pacific Coast Region							51.5	+1.7										72	2.36	−2.1									6.9		
Eureka	62	73	89	30.09	30.16	+.05	50.4	+3.2	69	16	57	34	14	44	22	46	42	76	2.73	−3.8	16	4,196	se.	28	s.	26	5	5	18	7.2	.0	.0
Redding	722	20	34	.....	.....	.....	50.3	.....	75	2	59	34	26	42	34	44	36	62	6.03	.....	12	4,696	nw.	25	nw.	22	4	6	18	7.7	.0	.0
Sacramento	66	92	115	30.08	30.16	+.07	50.0	−.1	66	18	58	33	25	42	27	46	42	76	1.97	−1.0	8	4,281	n.	20	nw.	24	7	11	10	6.0	.6	.0
San Francisco	155	208	243	29.98	30.15	+.05	54.1	+1.9	70	18	60	44	14	48	19	48	44	72	2.38	−1.5	9	4,265	nw.	26	nw.	23	6	7	15	6.7	.0	.0
South Pacific Coast Region							56.1	+2.2										66	2.95	+0.8									5.4		
Fresno	327	97	105	29.80	30.16	+.08	50.8	−.3	74	19	59	35	25	42	30	47	42	76	2.07	+.6	9	3,555	nw.	20	nw.	11	7	7	14	6.7	.0	.0
Los Angeles	338	159	191	29.72	30.09	+.03	60.0	+4.5	85	1	68	44	26	52	28	49	38	52	2.23	−.8	7	4,254	ne.	23	nw.	24	14	4	10	4.3	.0	.0
San Diego	87	62	70	29.99	30.08	+.02	57.4	+2.3	84	1	65	41	26	50	30	52	47	71	4.54	+2.5	8	4,084	nw.	25	w.	23	12	5	11	5.2	.0	.0
West Indies																															
San Juan, P. R.	82	9	54	29.95	30.04	.....	74.1	−.8	82	25	79	65	2	69	13	.....	.....	.....	6.46	+3.7	16	7,908	e.	29	ne.	22	8	16	4	5.2	.0	.0
Panama Canal																															
Balboa Heights	118	6	97	.....	[1] 29.89	+.04	79.6	−.7	92	24	88	67	17	71	21	.....	.....	[1] 77	.36	−.3	1	6,418	nw.	30	n.	28	4	24	0	4.5	.0	.0
Cristobal	36	6	97	.....	[1] 29.93	+.04	79.8	−1.0	86	20	84	70	17	76	15	74	72	80	3.10	+1.6	17	9,371	n.	28	n.	21	8	18	2	4.8	.0	.0
Alaska																															
Fairbanks	454	11	87	[2] 29.24	[2] 29.79	.....	7.4	.....	40	6	17	−22	3	−2	36	8	3	75	.41	.....	6	3,184	s.	19	ne.	18	1	7	20	7.8	9.1	17.8
Juneau	80	96	116	[2] 29.84	[2] 29.93	.....	37.0	.....	48	2	41	28	19	33	14	35	31	79	7.48	.....	18	5,362	s.	32	se.	2	2	2	24	8.9	1.8	T
Hawaiian Islands																															
Honolulu	38	86	100	[1] 30.05	[1] 30.09	.....	71.6	+.8	82	12	76	63	27	67	14	65	62	75	7.47	+3.7	10	6,368	e.	30	ne.	17	13	9	6	4.5	.0	.0

[1] Observations taken bihourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, February 1935*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48												
Halifax, Nova Scotia	88												
Yarmouth, Nova Scotia	65												
Charlottetown, Prince Edward Island	38												
Chatham, New Brunswick	28												
Father Point, Quebec	20												
Quebec, Quebec	296												
Doucet, Quebec	1,236				−0.6		15.3	−16.4	32	−50	1.31		13.1
Montreal, Quebec	187												
Ottawa, Ontario	236	29.76	30.05	+0.03	13.9	+2.2	23.5	4.3	38	−23	2.20	−0.49	12.9
Kingston, Ontario	285	29.70	30.04	.00	18.7	+.9	26.8	10.7	39	−14	1.75	−.79	8.0
Toronto, Ontario	379	29.60	30.06	+.02	22.4	+.9	28.8	15.9	48	−5	2.39	−.22	15.3
Cochrane, Ontario	930				7.2		17.6	−3.1	35	−28	.77		7.2
White River, Ontario	1,244												
London, Ontario	808				21.4		28.0	14.8	41	−8	3.48		23.6
Southampton, Ontario	656	29.30	30.04	+.02	17.8	−2.1	25.2	10.5	40	−18	1.36	−1.54	10.8
Parry Sound, Ontario	688	29.30	30.04	+.03	14.5	+.2	23.7	5.4	36	−22	1.97	−.95	14.4
Port Arthur, Ontario	644	29.34	30.07	+.02	16.4	+10.0	26.5	6.2	50	−19	.34	−.56	3.4
Winnipeg, Manitoba	760	29.25	30.12	+.02	15.8	+17.4	26.2	5.4	45	−20	.15	−.83	1.5
Minnedosa, Manitoba	1,690												
Les Pas, Manitoba	860												
Qu'Appelle, Saskatchewan	2,115	27.75	30.08	.00	18.2	+18.8	27.5	8.8	44	−16	.03	−.70	.3
Moose Jaw, Saskatchewan	1,759				21.8		30.8	12.8	47	−4	.09		.8
Swift Current, Saskatchewan	2,392	27.49	30.11	+.04	24.5	+16.5	33.5	15.4	47	−12	.33	−.41	3.3
Medicine Hat, Alberta	2,365	27.52	30.08	+.03	24.6	+13.4	32.7	16.4	52	−4	.20	−.47	2.0
Calgary, Alberta	3,540												
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.50	30.15	+.06	16.6	+19.6	26.7	6.5	44	−18	.42	−.27	1.7
Battleford, Saskatchewan	1,592	28.32	30.15	+.06	13.4	+13.3	25.9	.9	42	−28	.13	−.24	1.3
Edmonton, Alberta	2,150												
Kamloops, British Columbia	1,262												
Victoria, British Columbia	230	29.87	30.13	+.13	43.6	+4.1	48.0	39.3	54	30	.83	−3.27	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20												
Prince Rupert, British Columbia	170												
Hamilton, Bermuda	151												
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Cape Race, Newfoundland	99				26.1		32.6	19.6	44	−3	4.23		2.6
Sydney, Cape Breton Island	48	29.92	29.97	+.04	21.9	+1.4	30.3	13.5	49	−6	8.98	+3.88	45.0
Yarmouth, Nova Scotia	65	29.91	29.99	−.01	23.6	−2.7	30.8	16.5	51	2	6.51	+1.35	32.1
Charlottetown, Prince Edward Island	38	29.92	29.96	.00	15.7	−1.3	24.5	6.9	46	−14	6.70	+2.74	27.8
Chatham, New Brunswick	28	29.91	29.95	−.02	7.7	−2.1	17.5	−2.0	46	−36	3.75	+.16	27.9
Quebec, Quebec	296	29.79	30.14	+.12	5.4	−3.7	12.7	−1.9	41	−21	3.42	−.59	27.0
Doucet, Quebec	1,236				−10.1		4.6	−24.9	36	−60	2.07		20.5
Cochrane, Ontario	930				−7.9		3.4	−19.2	34	−44	3.04		30.4
Banff, Alberta	4,521	25.27	30.10	+.10	9.0	−3.1	19.0	−.9	46	−43	2.58	+1.39	22.8
Prince Albert, Saskatchewan	1,450	28.57	30.29	+.20	−11.4	−3.0	−4.0	−18.7	32	−54	.71	−.26	7.1
Kamloops, British Columbia	1,262	28.73	30.08	+.12	19.6	−3.4	25.8	13.4	48	−27	1.40	+.58	13.5
Estevan Point, British Columbia	20				40.6		45.5	35.7	63	10	30.36		13.5
Prince Rupert, British Columbia	170				31.3		35.8	26.8	54	5	6.84		11.8
Hamilton, Bermuda	151	29.94	30.11	−.02	61.5	−.5	66.0	57.1	75	50	4.62	−.32	.0

SEVERE LOCAL STORMS, FEBRUARY 1935

(Compiled by Mary O. Souder; authorities, U. S. Weather Bureau officials)

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Marshall, Tex., 4 miles east	8	6:15 p. m.	50	0	$3,000	Tornado	Hangar destroyed; 2 planes damaged.
Madisonville, Tex.	8	7–8 p. m.	[1] 3–4			Wind	Old, flimsy structures damaged.
Orange, Tex.	8	8–11 p. m.	33	0	4,500	Tornado	12 dwellings and outbuildings destroyed.
Groveton, Tex.	8	9 p. m.	[1] 1		30,000	Wind	Property damaged.
De Quincy, La.	8	11:10 p. m.		0	7,000	Tornado	Damage to buildings and merchandise; path short.
Grapeland, Tex.	8	P. m.	[1] 1	11		Wind	Residence, farm buildings and 31 tenant houses on Murray cotton plantation demolished; 11 Negroes killed and 40 injured.
Robertson, Brazos, Madison, Leon, Houston, San Jacinto, Polk and Trinity Counties, Mo.	8		[1] ¼–1½	13	200,000	Tornado	The storm was not continuous in its destruction, but seemed to lift from the ground and descend hitting various points throughout the counties; the longest continuous path was approximately 25 miles.
Augusta, Ga. (near)	12	P. m.		0		do	Roofs torn off and other property damaged; no injuries reported.
Macon, Ga., vicinity of	12		400	0		do	Several farm buildings and trees blown down; roof carried away; path 1 mile long.
Wrightsville, Ga. (near)	12			0	10,000	do	1 person injured; 14 tenant houses and a church razed; tornado, accompanied by torrential rains, made a path 10 miles long in timberlands, inflicting heavy damage.
Valdosta, Ga (near)	12					Severe wind	A number of houses and barns as well as several buildings of the convict camp damaged; a residence lifted from its foundation.
Colorado, eastern counties	21			1		Dust	Considerable damage in agricultural sections of eastern Colorado due to drifting of topsoil; man killed near Arriba when 2 section cars collided due to limited visibility because of dust; amount of damage not estimated.
Wichita, Kans., vicinity of	24	2 p. m.	10–100	0	10,000	Tornado	6 persons injured; property damaged; cow picked up from a barn lot by twister, carried 100 yards, and was unharmed; woman blown from the wreck of her home uninjured; path 9 miles long.
Elk and Wilson Counties, Kans.	24	4–4:30 p. m.	100–200	0	17,000	do	A few residences and many smaller buildings damaged; 5 persons injured, 1 seriously; path 20 miles long.
Montgomery County, Kans.	24	4:45 p. m.	30	0	150,000	do	14 residences wrecked and 20 others damaged; numerous garages and small buildings demolished; 1 person injured; path 3 miles long.
Ramona, Okla.	24	5–6 p. m.	[1] 2		10,000	Hail	Fruit trees damaged to some extent; $10,000 damage principally to roofs and windows.
Commerce to Century, Picher and Hockerville, Okla.	24	6:35 p. m.	100	1	27,500	Tornado	19 injured, 5 seriously; property damaged; path 10 miles long.
Cherokee County, Kans.	24	6:45 p. m.	33–66	0	15,000	do	Many small buildings demolished; poles, wires, and many trees blown down.
Joplin, Mo., vicinity of	24	7 p. m.	200–300	0	37,500	do	30 persons injured; property loss in Missouri estimated to be $37,500. Entered from Kansas.
Greenwood, Ark., 2½ miles southeast of.	24	9 p. m.	133	0	3,500	do	3 persons injured; property damaged.
Branch, Ark., vicinity of	24	9:30 p. m.		0	4,000	do	6 persons injured; property damaged; width of path narrow to 667 yards.
Lutherville, Ark., and vicinity.	24	10:30 p. m.	100	0	8,000	do	Property damaged.
Des Moines, Iowa	24–25					Snow	7 inches of snow recorded; traffic badly tied up; the driving snow on the afternoon of the 24th caused several accidents by greatly reducing the visibility.
Dubuque, Iowa	24–25					Wind and snow	Much drifting caused an ill effect on traffic, especially on country side-roads; 7.3 inches of snow on ground at 8:12 a. m. of the 25th.
Grand Rapids, Mich.	24–25					Snow and sleet	Snow to the depth of 8 inches fell from 6:55 p. m., of the 24th, to 12:55 a. m. of the 25th and was followed by sleet which formed a hard crust over the snow; highways blocked; transportation hampered; street cars stalled; ice on windshields made driving hazardous.
Omaha, Nebr.	24–25					Wind and snow	Traffic at standstill and country roads blocked for several days; depth of snow 6.6 inches.
Madison, Wis.	24–25					do	Roads blocked and traffic delayed.
Milwaukee, Wis.	24–25					Heavy snow and wind.	12.3 inches of snow fell and drifted; mist occurring on the morning of the 25th formed a crust over the snow; traffic seriously interfered with; outside work at standstill.
Gerber, Calif.	27		[1] 2			Hail	No crop damage; automobile tops and roofs of several houses damaged.

[1] Miles instead of yards.

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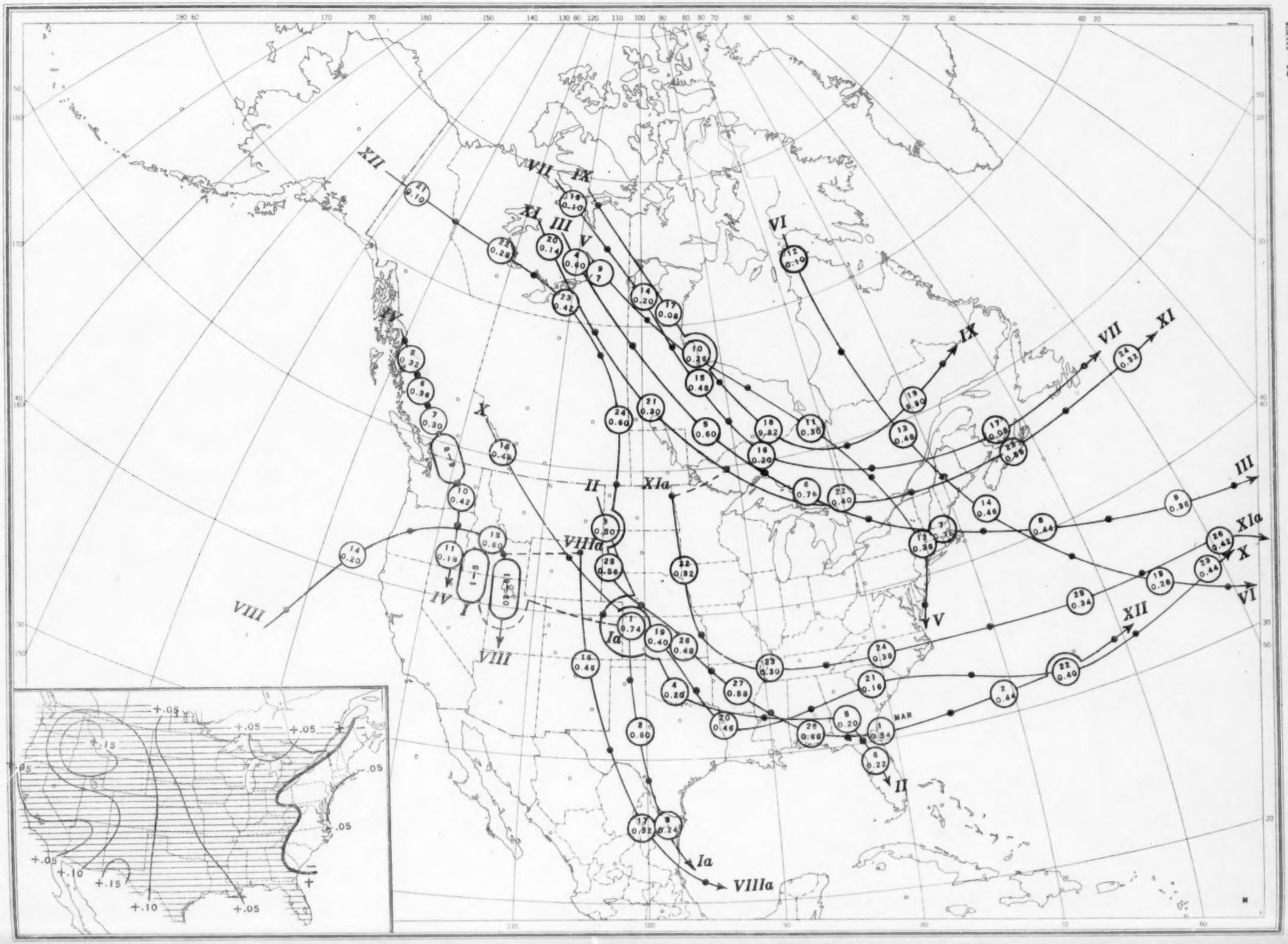
Chart I. Departure (°F.) of the Mean Temperature from the Normal, February 1935

Chart I. Departure (°F.) of the Mean Temperature from the Normal, February 1935

Shaded portions show excess (+)
Unshaded portions show deficiency (-)
Lines show amount of excess or deficiency
Statute Miles
Kilometers

Chart II. Tracks of Centers of Anticyclones, February 1935. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)



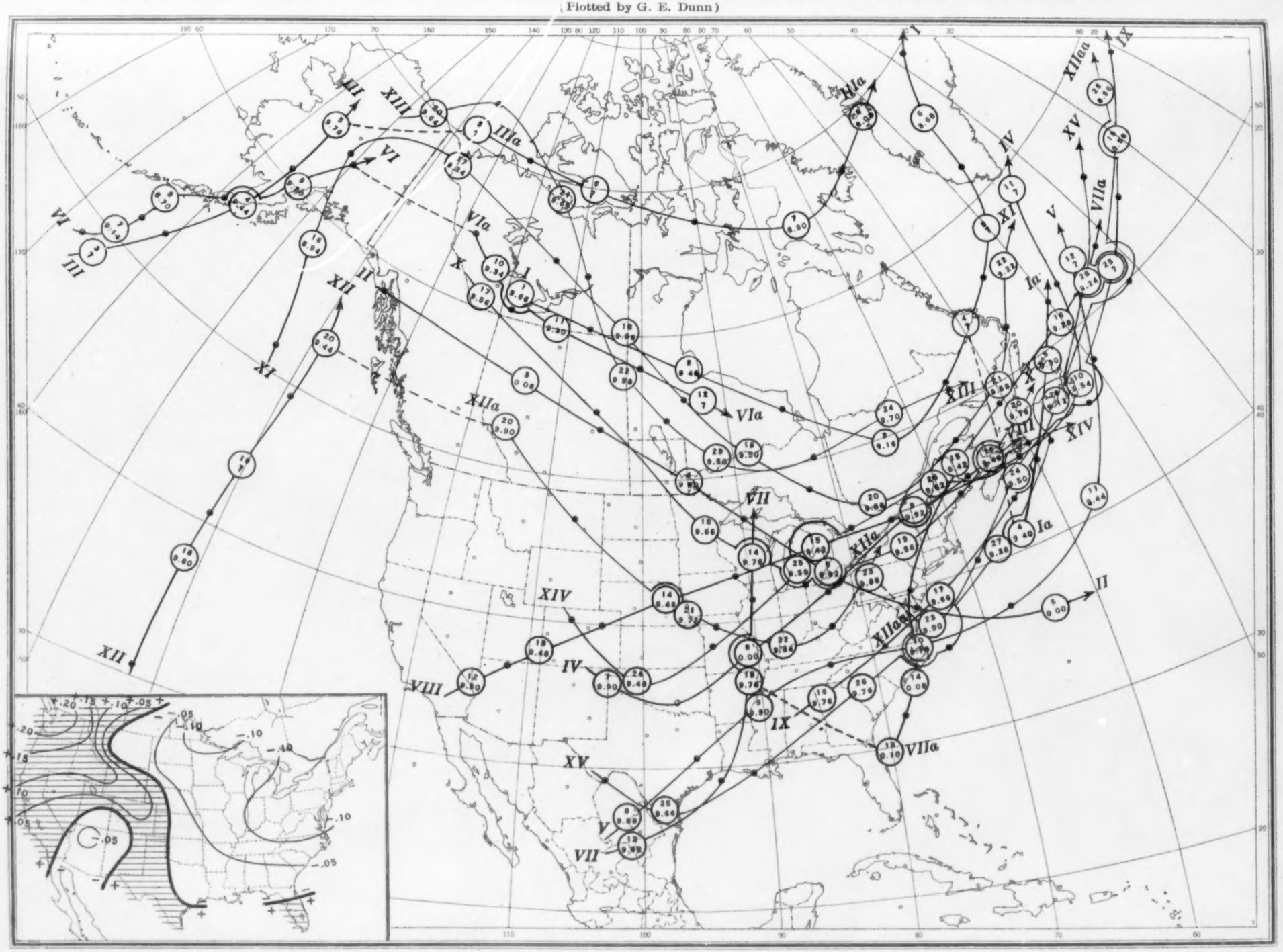
Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, February 1935. (Inset) Change in Mean Pressure from Preceding Month

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, February 1935. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, February 1935

Chart V. Total Precipitation, Inches, February 1935 (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, February 1935. (Inset) Departure of Precipitation from Normal

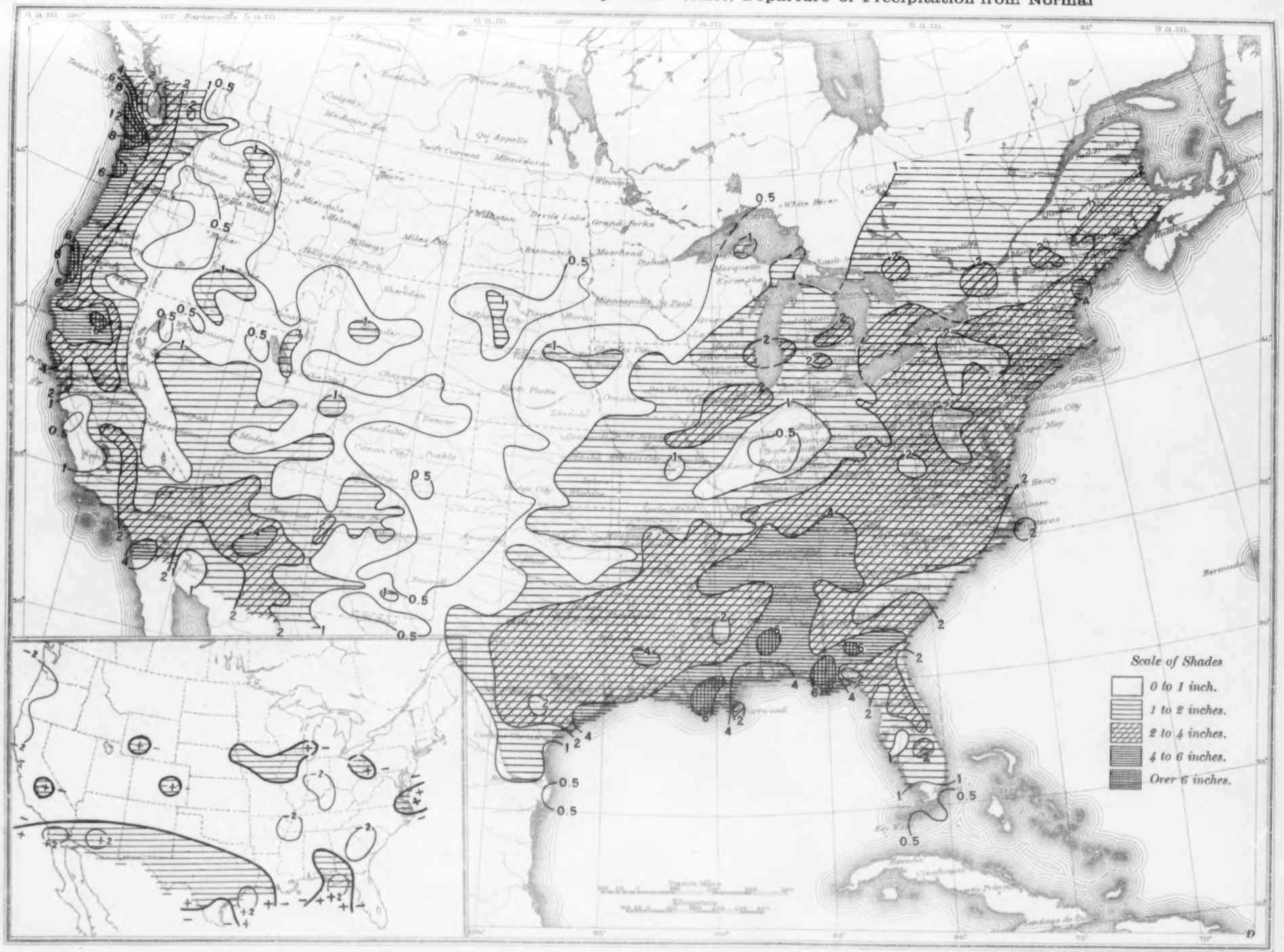


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, February 1935

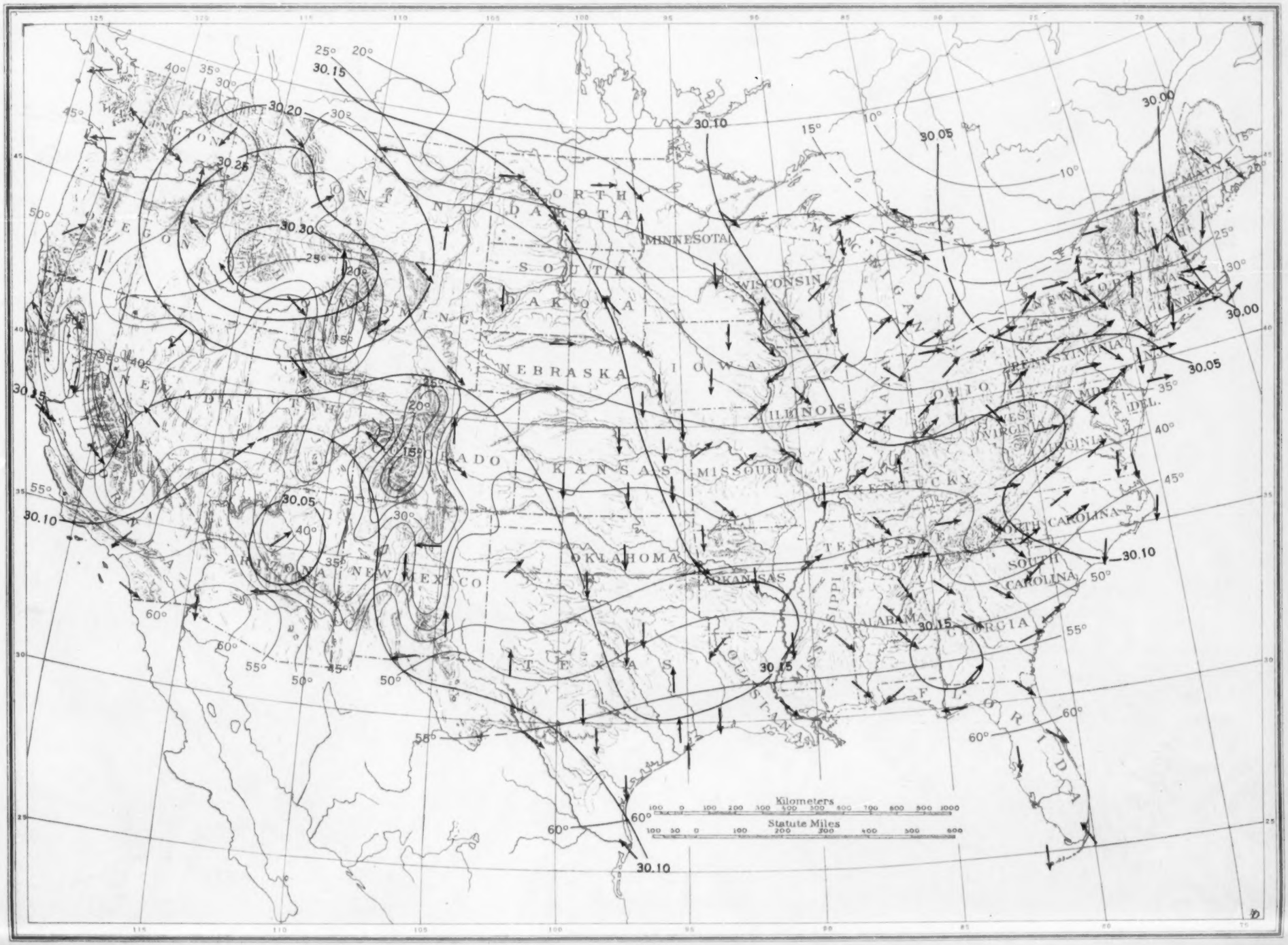


Chart VII. Wind Roses for Selected Stations, February 1935

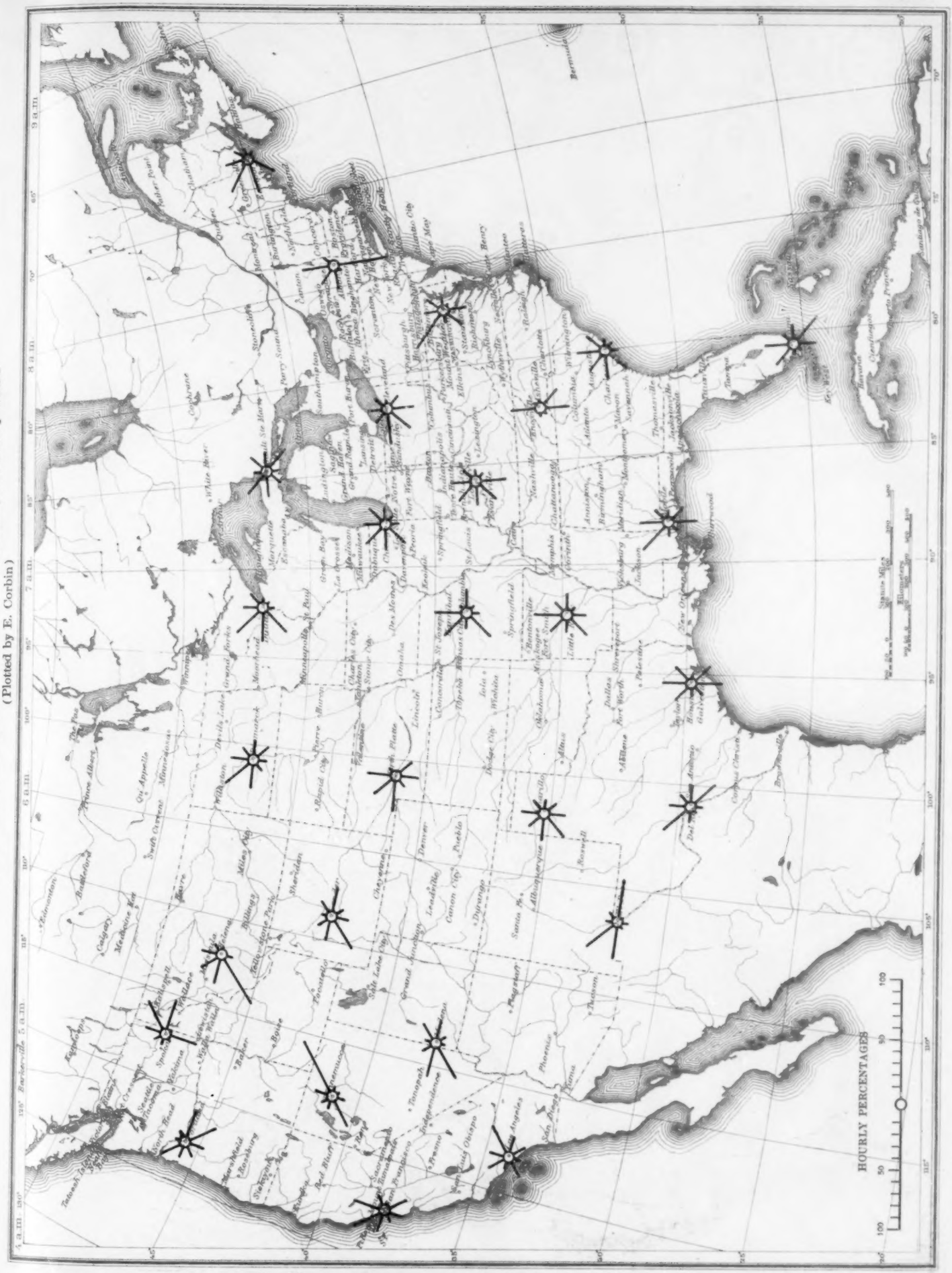


Chart VII. Wind Roses for Selected Stations, February 1935
(Plotted by E. Corbin)

Chart VIII. Total Snowfall, Inches, February 1935. (Inset) Depth of Snow on Ground at 8 p. m., Monday, February 25, 1935

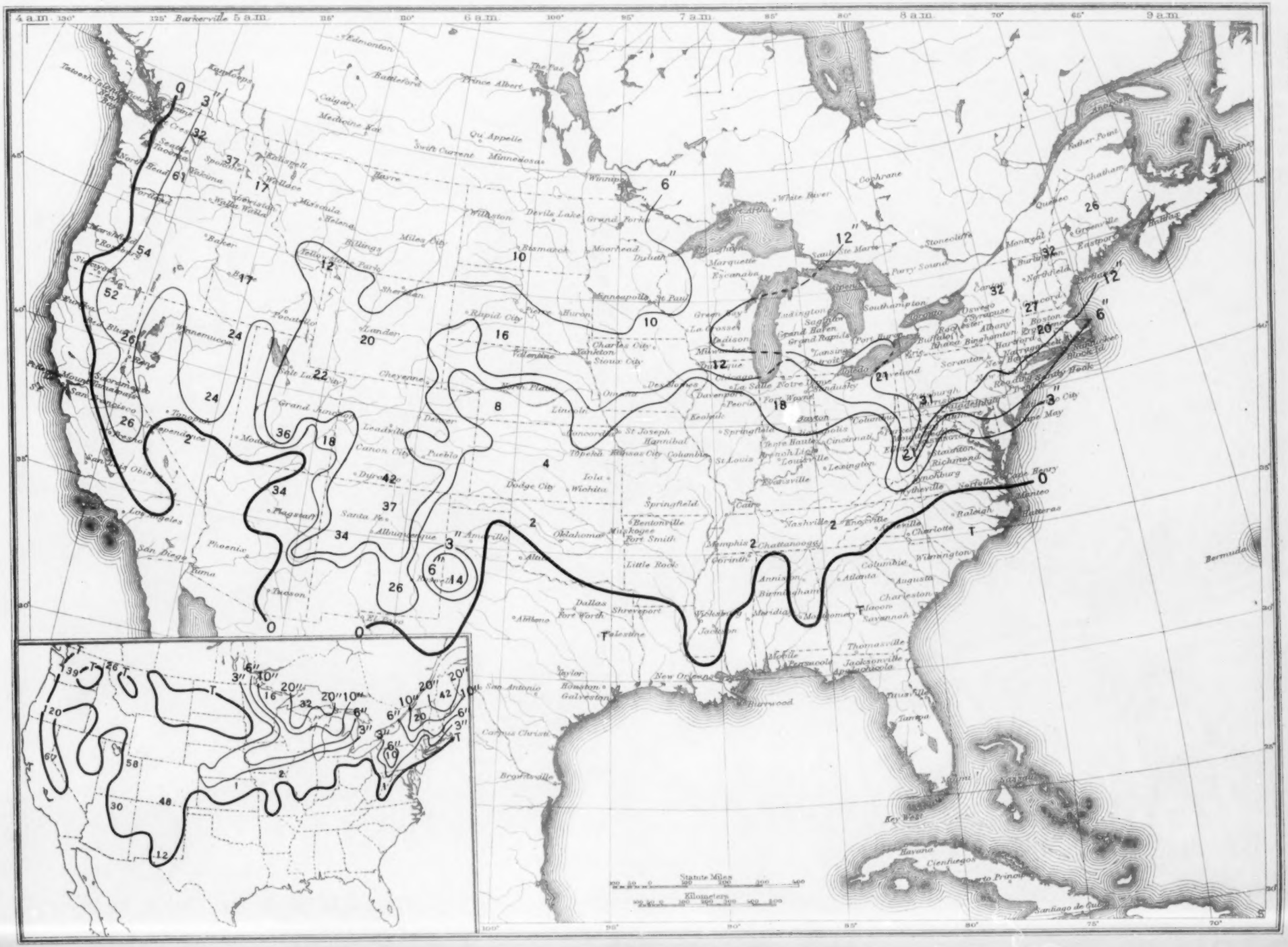
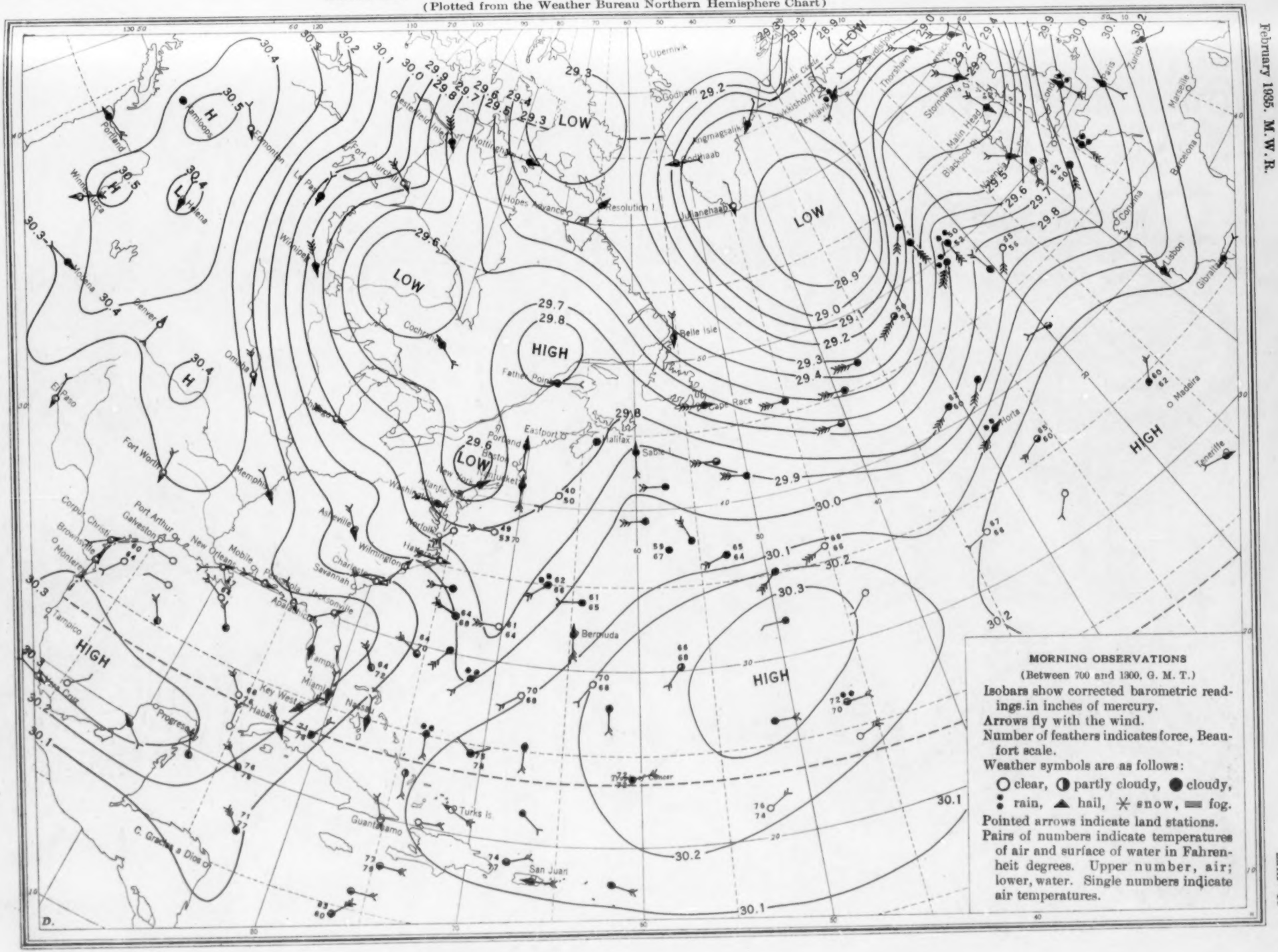


Chart IX. Weather Map of North Atlantic Ocean, February 19, 1935

(Plotted from the Weather Bureau Northern Hemisphere Chart)



MORNING OBSERVATIONS

(Between 700 and 1300, G. M. T.)

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicates force, Beaufort scale.

Weather symbols are as follows:

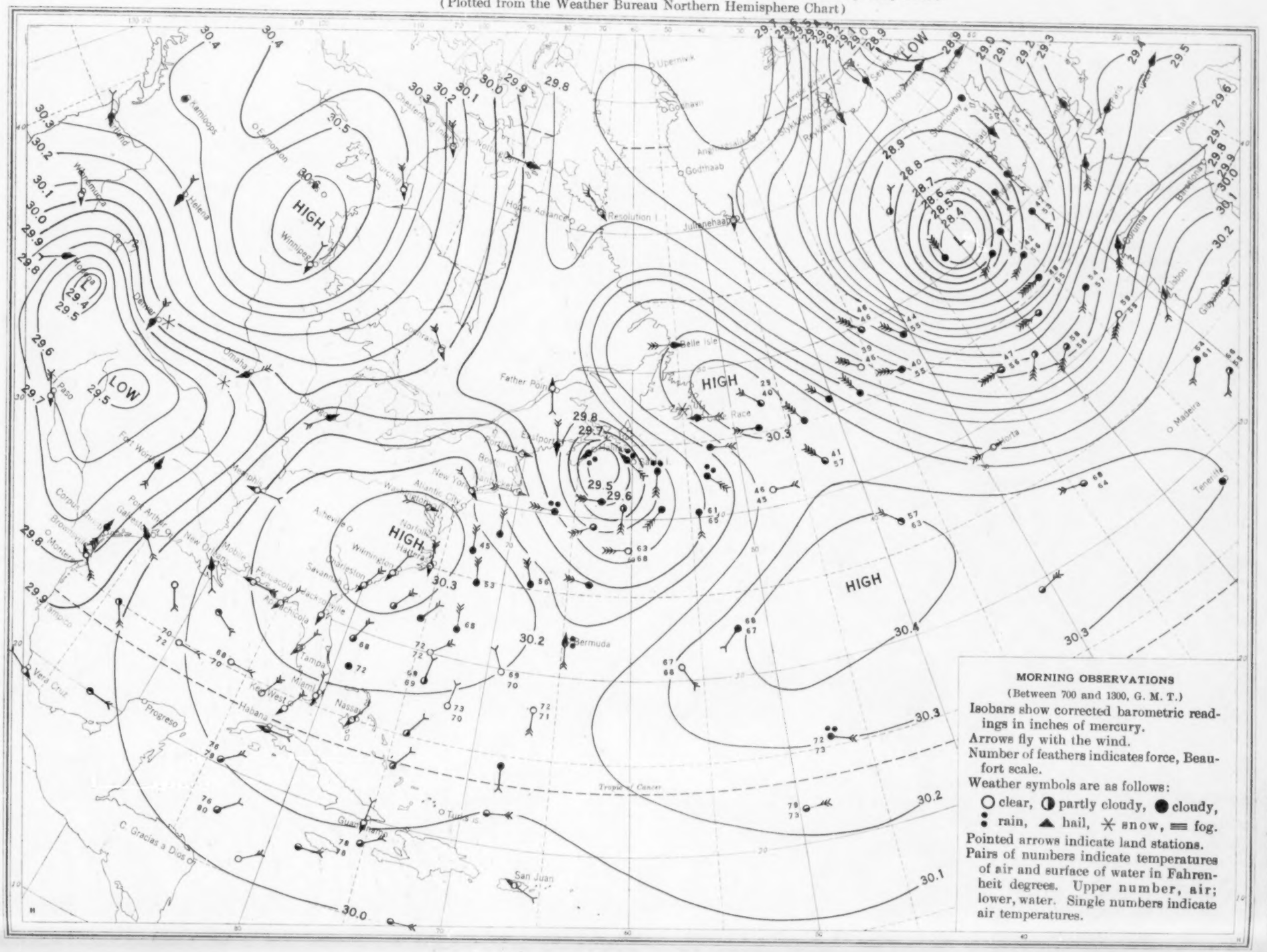
○ clear, ◑ partly cloudy, ● cloudy,
⁝ rain, ▲ hail, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.

Chart X. Weather Map of North Atlantic Ocean, February 24, 1935

(Plotted from the Weather Bureau Northern Hemisphere Chart)



MORNING OBSERVATIONS

(Between 700 and 1300, G. M. T.)

Isobars show corrected barometric readings in inches of mercury.

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⁝ rain, ▲ hail, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.